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THE REPRODUCTIVE BEHAVIOR OF THE SNAKE RIVER CUTTHROAT IN THREE TRIBUTARY STREAMS IN WYOMING

by
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SNAKE RIVER CUTTHROAT TROUT STUDY

PART I

The Reproductive Behavior of the Snake River Cutthroat in Three Tributary Streams in Wyoming

by

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Cooperative Research Project 4

Wyoming Game and Fish Commission

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ABSTRACT

The natural spawning of Snake River cutthroat trout (Salmo clarkii) in three tributary streams in Wyoming was studied in 1964, 1965 and 1966. These streams, Blue Crane Creek, Fish Creek, and Bar BC Spring Creek were low gradient, productive streams containing large areas of good spawning gravel and cover. The study included evaluation of the timing, duration, age and sex composition of spawning runs and the fecundity and post-spawning mortality of spawners. Estimates of cutthroat trout population densities, egg mortality, and fry mortality were made and physical and chemical conditions in the streams were measured.

Cutthroat trout spawned in Blue Crane Creek during April, in Fish Creek during late April, May, and early June, and in Bar BC Spring Creek during June and July. The temperature characteristics of these streams could not be correlated with the timing of the spawning runs. Sex ratios did not vary much from one to one. In 1965, 87.4 percent of the spawners in Fish Creek and 84.4 percent of those in Bar BC Spring Creek were age III and IV. The majority of cutthroat males were age III while the majority of females were age IV.

In 1965, an estimated 45.6 percent of adult spawners died in Bar BC Spring Creek, while in 1966, 53.5 percent died. Consecutive repeat spawners composed 19.0 percent of the 1966 Bar BC Spring Creek spawning run. Numerous instances of homing behavior were observed and three instances of straying between the three study streams were also noted.

TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
DESCRIPTION OF THE STUDY AREA	7
Blue Crane Creek	7
Fish Creek	10
Bar BC Spring Creek	13
METHODS	19
Physical and Chemical	19
Spawning and Migration Observations	19
Fecundity Analysis	21
Egg Mortality Studies	21
Population Estimates	22
Age-Growth Study	23
RESULTS	25
Physical and Chemical	25
Volume Flows	26
Weather Data	26
Timing and Duration of Cutthroat Trout Spawning Runs.	35
Choice of Spawning Areas	44
Numbers of Cutthroat Trout Spawning	45
Sex Composition of the Spawning Runs	47
Age Composition of the Spawning Runs	49
Post-Spawning Mortality of Cutthroat Trout	52

PAGE

Consecutive Spawning by Cutthroat Trout..... 56

Homing Behavior of Cutthroat Trout..... 57

Population Estimates..... 58

Fish Creek..... 58

Bar BC Spring Creek..... 65

Fecundity of Cutthroat Trout Spawners..... 75

Mortality of Cutthroat Trout Eggs..... 76

Mortality of Cutthroat Trout Fry..... 80

Downstream Migration of Immature Cutthroat Trout..... 82

Growth of Cutthroat Trout Fry..... 91

Upstream Migration of Immature Cutthroat Trout..... 93

Age and Growth of Cutthroat Trout..... 93

SUMMARY..... 99

CONCLUSIONS AND RECOMMENDATIONS..... 103

BIBLIOGRAPHY..... 106

LIST OF TABLES

Table		Page
1.	Water chemistry data for the Snake River and the study tributaries	27
2.	Mean water temperatures in the study area during cutthroat trout spawning runs	33
3.	Timing of cutthroat trout spawning runs through fish traps in three Snake River tributaries	40
4.	Sex composition of cutthroat trout spawning runs in three Snake River tributaries	48
5.	Age composition of cutthroat trout spawning runs trapped in two Snake River tributary streams	51
6.	Percent by sex of cutthroat trout spawners in various age groups trapped in two Snake River tributary streams.	51
7.	Fish captured during 1964 electro-fishing operation in Fish Creek	60
8.	Fish captured during 1965 electro-fishing operation in Fish Creek	61
9.	Fish captured during 1966 electro-fishing operation in Fish Creek	61
10.	Number and composition of the calculated cutthroat trout population in the upstream study sections of Fish Creek	62
11.	Number and composition of the calculated cutthroat trout population in the downstream study sections of Fish Creek	62
12.	Fish captured during 1964 electro-fishing operation in Bar BC Spring Creek	68
13.	Fish captured during 1965 electro-fishing operation in Bar BC Spring Creek	69
14.	Fish captured during 1966 electro-fishing operation in Bar BC Spring Creek	70

Table Page

15. Estimate of total fish population in Bar BC Spring Creek in 1964, 1965, and 1966..... 70

16. Mortality of cutthroat trout eggs from natural redds in Bar BC Spring Creek..... 71

17. Average total length by week of young-of-the-year cutthroat trout trapped in three Snake River tributaries..... 92

18. Calculated life history of cutthroat trout from Blue Crane Creek..... 97

19. Empirical length and weight of different age classes of cutthroat trout from the Snake River and two tributary streams..... 98

LIST OF FIGURES

Figure		Page
1.	Snake River Study Area	5
2.	The Snake River in the southern portion of Jackson Hole	6
3.	Blue Crane Creek study area	8
4.	Fish Creek study area	11
5.	Bar BC Spring Creek study area	14
6.	Blue Crane Creek near the Fish Ladder	17
7.	Fish Creek near the Fish Trap	17
8.	The upstream section of Bar BC Spring Creek	18
9.	Blue Crane Creek mean water temperatures	28
10.	Fish Creek mean water temperatures	29
11.	Bar BC Spring Creek mean water temperatures	30
12.	Snake River mean water temperature	31
13.	Gros Ventre River mean water temperature	32
14.	Snake River volume flows	34
15.	Mean monthly air temperatures for 1964, 1965 and 1966	36
16.	Monthly precipitation for 1964, 1965 and 1966	37
17.	Cutthroat spawning runs through the Blue Crane Creek trap	41
18.	Cutthroat spawning runs through the Fish Creek trap	42
19.	Cutthroat spawning runs through the Bar BC Spring Creek trap	43
20.	Fish Creek electro-fishing sections	59

Figure		Page
21.	Bar BC Spring Creek electro-fishing sections.....	66
22.	Fingerling cutthroat migrating downstream in Blue Crane Creek.....	83
23.	Age I and II cutthroat migrating downstream in Blue Crane Creek.....	84
24.	Fingerling cutthroat captured in downstream traps in Fish Creek.....	87
25.	Fingerling cutthroat captured in downstream traps in Bar BC Spring Creek.....	88
26.	Aquatic vegetation in Bar BC Spring Creek.....	90
27.	Relationship between body length and anterior scale radius length of Blue Crane Creek cutthroat trout.....	94
28.	Length-weight relationship of Blue Crane Creek cutthroat trout.....	96

INTRODUCTION

The Snake River drainage in Wyoming is a complex water system originating near the Continental Divide just south of Yellowstone National Park. Although this drainage area of 3,465 square miles is one of the smallest of major drainages in Wyoming, the Snake River itself carries the largest average volume of any river in the state. United States Geological Survey records indicate that the average discharge from 1953 through 1965 near the Wyoming-Idaho state line was 4,425 cubic feet per second or 3,204,000 acre feet per year. From its origin, the Snake River flows southwesterly for some forty miles into Jackson Lake in Grand Teton National Park. It then flows southerly from Jackson Lake for about eighty miles in Wyoming before entering Idaho. Major tributaries flow into the Snake River from the east and south. The streams of this drainage are typically of moderate gradient with average to good cover and an abundance of food.

The Snake River and its tributaries in Wyoming are presently providing an excellent sport fishery. In the Snake River itself, this fishery is maintained for the most part by natural reproduction of the cutthroat trout, Salmo clarkii Richardson. The Snake River cutthroat trout has been variously considered as a distinct, fine-spotted race or variety of the cutthroat series. Simon (1946) considered the Snake River cutthroat as belonging to the Yellowstone cutthroat group (Salmo clarkii lewisi). Whatever its taxonomic status, the population of cutthroat trout inhabiting the Snake River and its tributaries in Wyoming represents one of the few

remaining naturally-reproducing populations of this species in the United States. For this reason, this population is of great economic and esthetic value.

Angling pressure on the Snake River cutthroat trout population has been increasing for a number of years and there is reason to believe that this trend will continue. At the same time, the demand for irrigation water downstream is increasing and several proposals for the construction of high dams in the Snake River drainage of Wyoming have been made. In the face of increased demands on the fishery and possible future loss of river habitat, it is imperative that the life history of the Snake River cutthroat trout be studied. If the present quality of this fishery is to be maintained, a sound fisheries management program based on good biological information must be initiated.

This study is the first segment of a long-term study of the ecology of the Snake River cutthroat trout population. The major objective assigned to this study was to investigate the various aspects of natural reproduction in the population. Fisheries personnel of the Wyoming Game and Fish Department have known for a number of years that many cutthroat trout from the Snake River spawn in various tributary streams. In 1959, area fisheries management personnel surveyed all tributary streams entering the Snake River between the Wyoming-Idaho state line and the Jackson Lake dam. In an unpublished 1960 progress report entitled "Evaluation of the Snake River Cutthroat Trout Fishery" they reported that in a total of thirty-six streams, twenty-one had no spawning for various reasons, five had limited spawning, and ten were either considered good spawning streams or thought to have good spawning potential. Since this survey was made, three streams reported

at that time as having no spawning have been improved by the removal of barriers. Some of the larger tributaries (Hoback, Gros Ventre, and Buffalo Fork Rivers, Pacific and Spread Creeks) have no known cutthroat spawning although they are considered to have good spawning potential. At least one excellent spawning tributary, Flat Creek, has deteriorated recently because of extensive siltation originating from an irrigation diversion.

The possibility that cutthroat trout may spawn in channels of the Snake River has not been overlooked, but no evidence of such spawning has ever been observed by fisheries management personnel. It may be that opportunities for natural reproduction in the Snake River proper are limited. For nearly fifty miles immediately south of the Jackson Lake dam the bed of the Snake River is composed mostly of rounded cobbles and gravel. The extensive area of braided channels in the south portion of Jackson Hole indicate that this river bed is relatively unstable. Flood control levees have been constructed on about twelve miles of the Snake River immediately south of Grand Teton National Park to confine the River to its present stream bed. Before the construction of these levees, shifting channels of the Snake River had annually encroached on deeded land. The shifting nature of the river bed and extreme water level fluctuation associated with the annual spring run-off would appear to limit the chances of successful reproduction for a spring-spawning species such as the cutthroat trout. It may be that the tributary streams are very important in maintaining the Snake River cutthroat trout fishery.

In the present study, three tributary streams were selected for investigation. All are of low gradient, comparatively productive, and known to be good spawning streams for cutthroat trout. All are wholly

or in part spring fed and are located on river bottom land in a twenty mile section immediately south of Grand Teton National Park. From north to south, these streams are designated as Bar BC Spring Creek, Fish Creek, and Blue Crane Creek. The investigation of these three tributary streams had the following general objectives:

(1) To measure the size, duration, timing, age composition and sex ratio of cutthroat trout spawning runs. In addition, to determine the size, fecundity, and post-spawning mortality of cutthroat trout spawners.

(2) To determine the numbers and distribution of cutthroat trout redds and the mortality of eggs in these redds.

(3) To determine the rate of growth and mortality of cutthroat trout fry and fingerlings.

(4) To determine the timing and rate of movement of young cutthroat trout from these streams to the Snake River.

In 1962, the Wyoming Game and Fish Department began trapping fish in Blue Crane Creek. As Blue Crane Creek and Spring Creek are confluent for a short distance, it was recognized that only a portion of the spawning run and downstream movement of cutthroat trout was being trapped. This study was originally conceived as being confined to Blue Crane and Spring Creeks. Another fish trap was to be built at the mouth of Spring Creek and the entire creek complex could then be studied. As both Spring Creek and Blue Crane Creek flow over private lands, the permission of the landowners was solicited. When they did not feel that a project of this extent was acceptable, another study area had to be found. Fish Creek and Bar BC Spring Creek were then selected as additional study areas.

Fig. 1. Snake River Study Area, Teton County, Wyoming

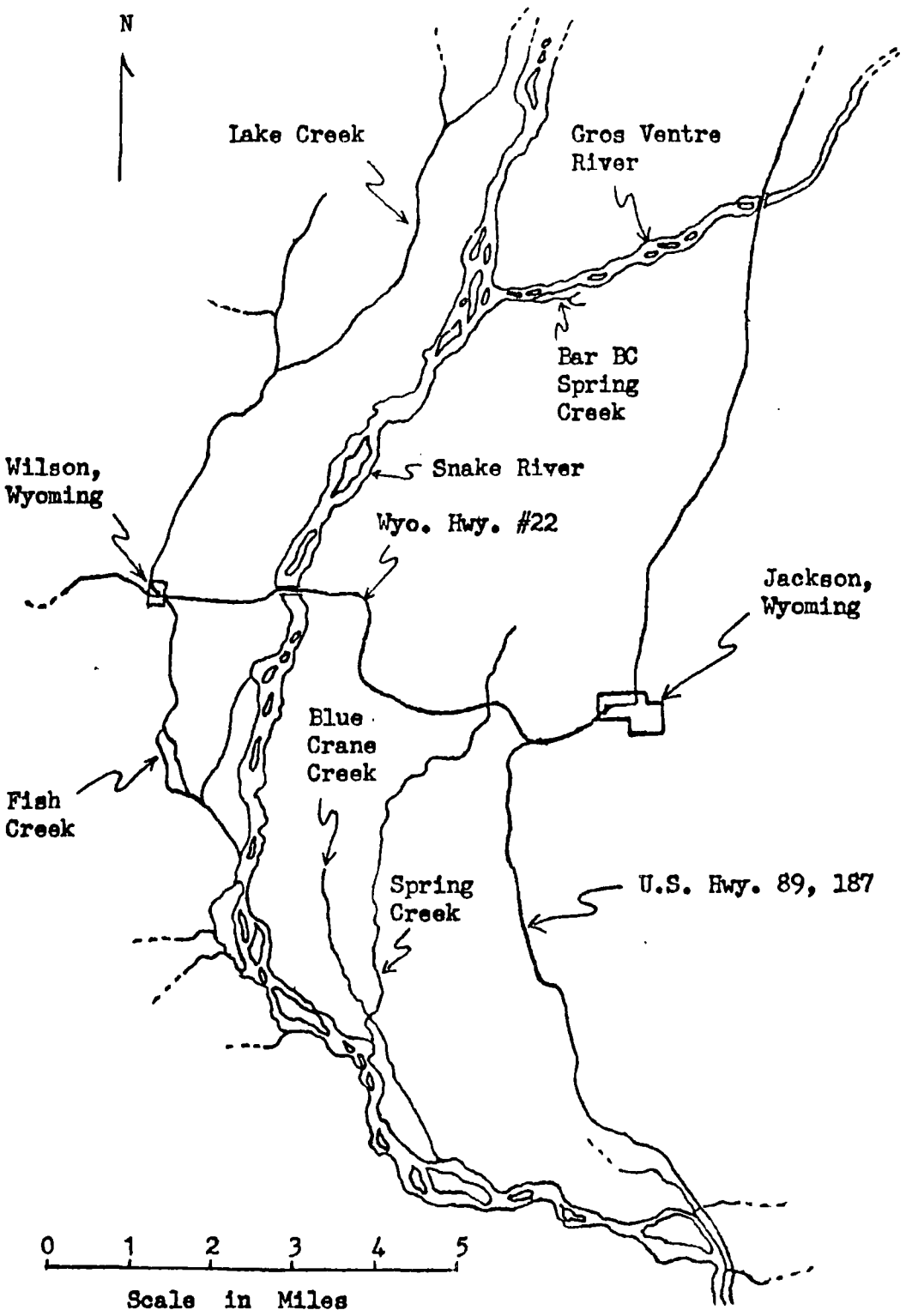


Figure 2. The Snake River in the southern portion of Jackson Hole.

DESCRIPTION OF THE STUDY AREA

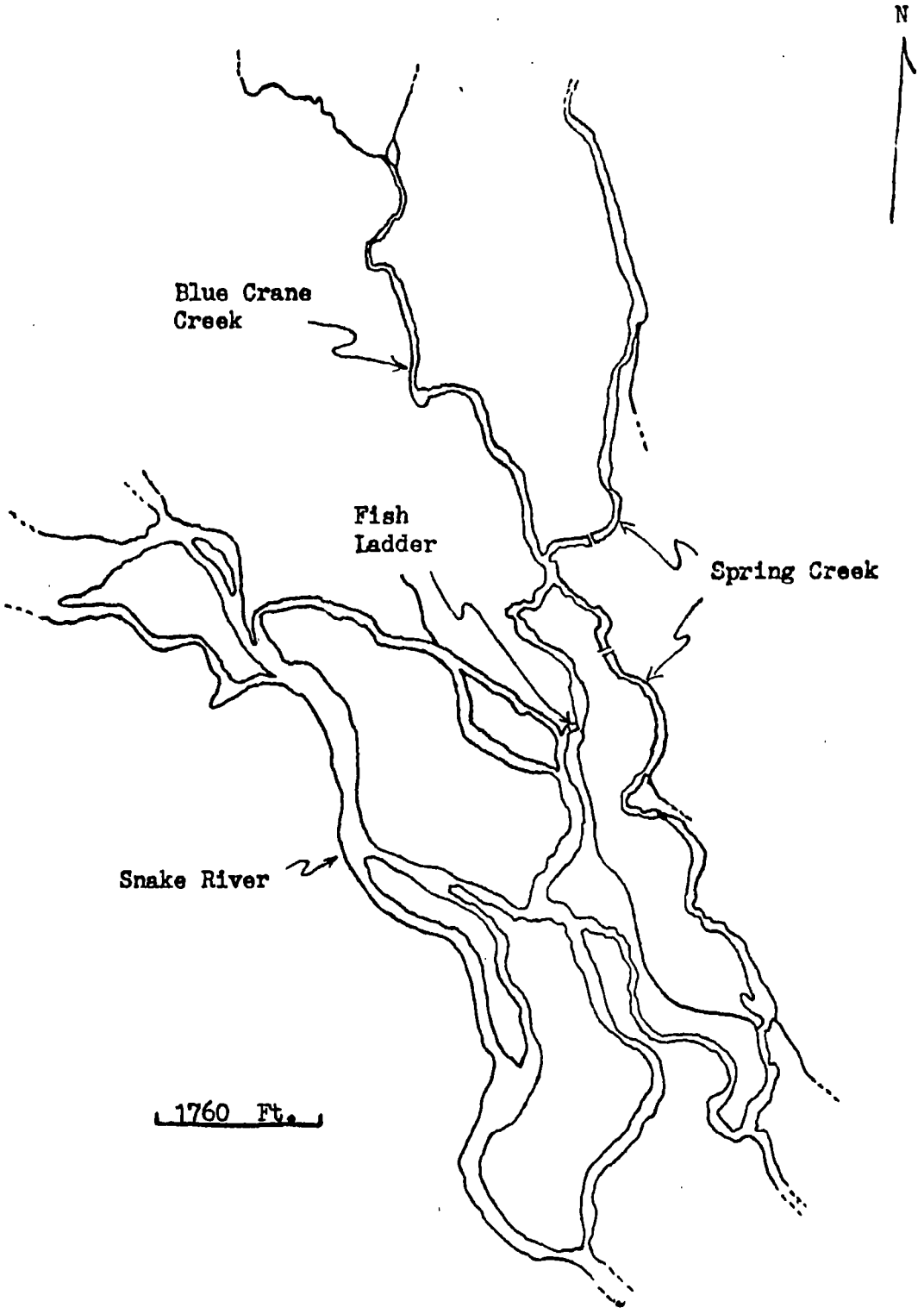
Blue Crane Creek

The entire three-mile length of Blue Crane Creek lies in bottom lands on the east side of the Snake River. The study section included only the lower 9,400 feet of stream, since the upper section was blocked by numerous barriers. This study section was located in sections 11, 12, 13 and 24, Township 40 North, Range 117 West. The entire creek and its tributaries flow over private lands.

Blue Crane Creek arises from several springs, flows south picking up several spring-fed tributaries and enters the Snake River. Gradient is low throughout its entire length, being fifty feet or less per mile. The annual water level fluctuation is normally not great. Stream flows measured in August averaged about 85 cubic feet per second near the mouth of the creek. The lowest water levels occur during the winter and the highest water levels in the early and middle summer. Supplemental irrigation water from the Snake River drained into Blue Crane Creek in several places during the irrigation season of July and August.

Hay was harvest from meadows near the source of the stream, but the major land use in the immediate area was livestock grazing. Bank cover is excellent as Blue Crane Creek flows mostly through wooded area. Grasses, sedges and various annuals were very abundant along the course of the stream. The dominant vegetation was narrow-leaf cottonwood, Englemann spruce, willow and alder.

Fig. 3. Blue Crane Creek Study Area



Aquatic and semi-aquatic vegetation was abundant along the whole course of the creek. The most common species were pondweed, white water-crowfoot, and water cress. Water cress was confined mostly to shoreline areas, pondweed to areas of silt bottom, and white water-crowfoot to areas with gravel or rocky bottom. Other submerged aquatic plants less commonly encountered were star duckweed, water milfoil, liverwort, and stonewart. The most common emergent aquatic plants were mare's tail, and monkey flower. During the late summer and early autumn, at least 80 percent of the creek bottom was covered by aquatic vegetation. Most of this covering had broken down and washed away by mid-winter and during the cutthroat trout spawning period, there was very little vegetation present on the creek bottom.

Stream bed material consisted of silt, cobbles and gravel. In the study section 51.5 percent of the creek bottom was of cobbles or gravel, 43.5 percent was of silt and five percent consisted of deep holes with mostly cobble bottom. Silt typically accumulated in areas of low water velocity and was usually found where beaver dams or irrigation diversions had been constructed. Several beaver dams were removed from the creek in the last five years, but little movement of silt from these areas was observed.

One unusual feature of this creek is that it becomes confluent with Spring Creek for about 100 feet and then branches off again. About 50 years ago, both Spring Creek and Blue Crane Creek emptied into the Snake River through the present lower section of Blue Crane Creek. An irrigation diversion was dug below the point where they joined to irrigate haylands to the south. This diversion, now called Spring Creek, has become a well-developed stream, and carries more water than does the original channel. In 1956, the mouth of Blue Crane Creek was dammed and a ditch was constructed to irrigate land between Spring Creek and the Snake River. In 1960, the landowner had

a fish ladder installed at his own expense in an attempt to re-establish the cutthroat trout spawning run that had been cut off.

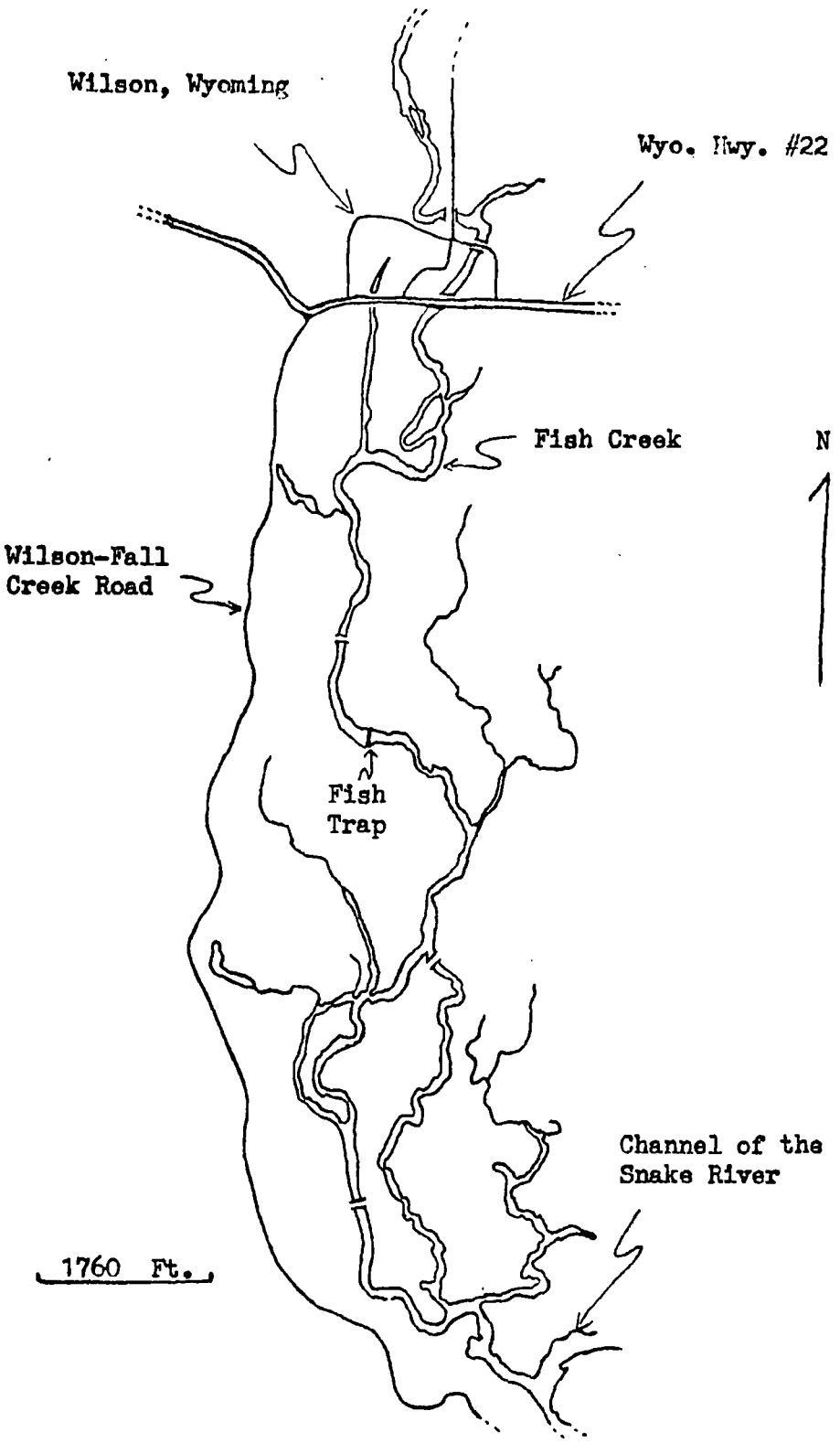
The cutthroat trout was the most abundant species observed in Blue Crane Creek. Brook trout were found throughout the creek, but appeared to be somewhat more abundant near the headwaters. One lake trout was captured in the overpour trap in 1964. This species is found occasionally in many streams in the upper Snake River drainage. Rainbow trout and rainbow cutthroat hybrids were occasionally captured in the overpour trap. It was assumed that these fish came from the Gros Ventre River, where a small rainbow population is known to exist, by way of irrigation diversions draining into the source of Spring Creek. Other fish species commonly encountered in Blue Crane Creek were mountain whitefish, redside shiner, Utah sucker, longnose dace, speckled dace, and mottled sculpin. Other species present but rarely seen were mountain sucker and Utah chub.

Fish Creek

Fish Creek arises from springs along the eastern flank of the Teton Range about five miles north of Wilson, Wyoming. It flows south through the town of Wilson, and enters a channel of the Snake River about two and one-half miles below. A major tributary is Lake Creek which flows from Phelps Lake at the mouth of Death Canyon in Grand Teton National Park. This tributary flows eastward from the lake, turns abruptly south near the Snake River and flows across flat haylands into Fish Creek. Lake Creek usually flows in the summer months and goes dry late in the fall. Irrigation water taken from the Snake River flows into Lake Creek and also into Fish Creek.

Most of this investigation was confined to the lower 9,600 feet of Fish Creek. This portion is located in sections 24, 27, and 34, Township 41 North, Range 117 West. Because of the large size of Fish Creek, only general observations could be made on cutthroat trout spawning activity. Stream-flows at

Fig. 4. Fish Creek Study Area



Wilson varied from 150 cfs to nearly 1,000 cfs during the early summer run-off. Gradient is low, being fifty feet or less per mile. At low water, the average stream width south of Wilson is about sixty-five feet. Several large spring-fed tributaries contribute to Fish Creek near its mouth. Stream banks along most of the creek average two to three feet in height, and during periods of high water, some flooding of adjacent land often occurs.

The upper portion of Fish Creek flows through haylands. Major land use in the lower two miles of stream was livestock grazing. Willows were abundant along much of the creek and bank stability was generally good. In the town of Wilson, numerous dwellings have been constructed on or near the stream bank. All sewage treatment is by septic tanks and it is probable that some pollution of Fish Creek occurs.

Aquatic vegetation was quite abundant in Fish Creek. The species observed were those found in Blue Crane Creek. The most abundant species was white water-crowfoot which occurred in large beds on the stream bottom throughout much of the lower three miles of stream. Water cress was locally abundant in spring channels and backwaters. Pondweed occurred where the creek bed was covered with silt.

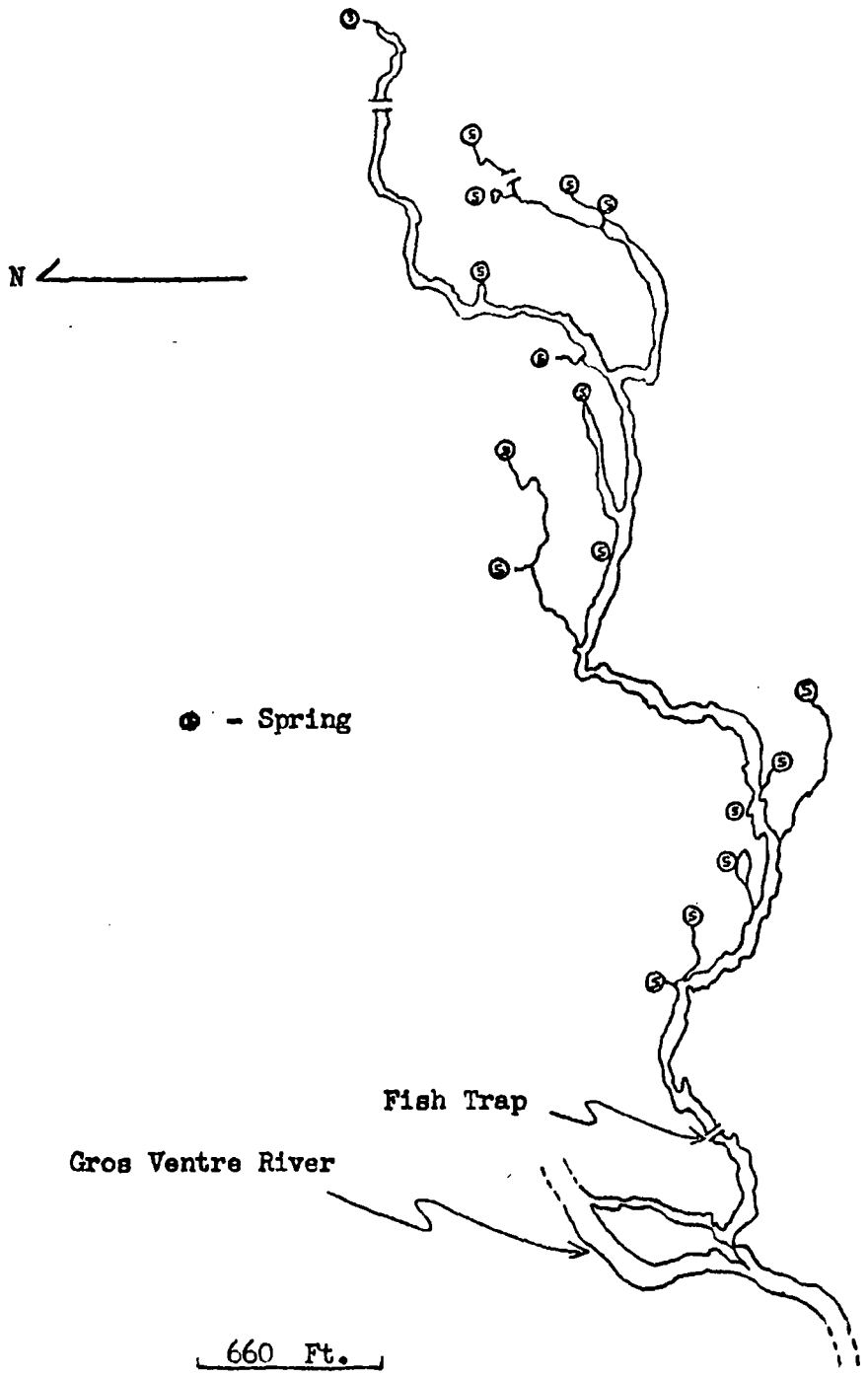
Cobbles and gravel were the most common stream bottom material. Silt was found mostly in areas where irrigation diversions or stream improvements had been constructed and was less common than in Blue Crane Creek. A number of log-dam stream improvement structures have been constructed in the lower two miles of Fish Creek and in a section immediately north of the town of Wilson. In 1966, rock-flare dams and retards were placed in the creek two and one-half miles north of Wilson.

The mountain whitefish was the most abundant fish species observed in Fish Creek. Cutthroat trout, Utah sucker, brook trout, and mottled sculpin were also abundant in this creek. Other species less commonly observed were mountain sucker, longnose dace, speckled dace, and redside shiner. Lake trout, rainbow trout, and rainbow-cutthroat hybrids were occasionally captured in the fish trap. One Utah chub was also trapped. Cutthroat trout were found throughout the creek while brook trout were more common in the portion of the creek north of Wilson, Wyoming. Most whitefish were observed in the lower portion of the creek where deep holes were more abundant. Large concentrations of whitefish were also observed in deep holes north of Wilson. During this study, large numbers of whitefish were observed to migrate upstream before the spring run-off and to migrate back downstream during the late summer and fall. Fish tag returns from several thousand whitefish tagged in Fish Creek in 1958 indicated that many of these fish migrated into the Snake River during the winter.

Bar BC Spring Creek

Bar BC Spring Creek arises from springs south of the Gros Ventre River, flows westward and enters the Gros Ventre about one-half mile above its confluence with the Snake River. The total length of this creek is about 7,500 feet. It is located in sections 4 and 5, Township 41 North, Range 116 West. The volume-flow is approximately 40 cfs near the mouth and annual fluctuation is very slight. Although Bar BC Spring Creek is not tributary to the Snake River proper, past fish tagging records indicated that cutthroat trout from the Snake River utilized this creek for spawning.

Fig. 5. Bar BC Spring Creek Study Area



Gradient is less that fifty feet per mile. The major land use in the immediate vicinity of the creek was livestock grazing. Hay was cut from fields located to the south and some irrigation run-off water entered the creek in the summer. Bank cover was excellent. Grasses, sedges, willow and alder were abundant along the stream. The dominant trees were Engelmann spruce and narrow-leaf cottonwood.

About 65 percent of the stream bottom was cobbles or gravel and about 35 percent was silt. During the investigation it was observed that considerable quantities of silt were washed out of the creek. Riffles comprised about 50 percent of the total stream distance, pools the other 50 percent. About 5 percent of the total stream distance consisted of holes with depths of over three feet. The average stream width of the lower 3,000 feet was about thirty feet and the average depth in this area was about fourteen inches.

Aquatic plants were very abundant in Bar BC Spring Creek. The species present were those found in Blue Crane Creek and Fish Creek except water milfoil and star duckweed which was not observed. By far the most abundant species found was water cress. This plant increased throughout the summer and reached a peak in October. It covered the creek bottom in many areas and formed extensive islands of vegetation on which filamentous algae often became abundant. Approximately 75 percent of the creek bottom was covered with water cress in late October. As in the other two creeks, pondweed was found in areas of silt bottom. Most of the vegetation had broken down and washed out of the creek by the end of January.

The brook trout was the most abundant resident fish species observed in Bar BC Spring Creek. Cutthroat trout was also abundant during the early part

of their life cycle, but comparatively few cutthroat were resident throughout the year. The only other common species in the creek was the mottled sculpin. A few mountain whitefish spawned in this creek and a number of age 0+ whitefish were captured during electro-fishing work. Other species occasionally observed in the creek were rainbow trout, rainbow-cutthroat hybrids, and a single mountain sucker.

Figure 6. Blue Crane Creek near the fish ladder.

Figure 7. Fish Creek immediately downstream from the fish trap.

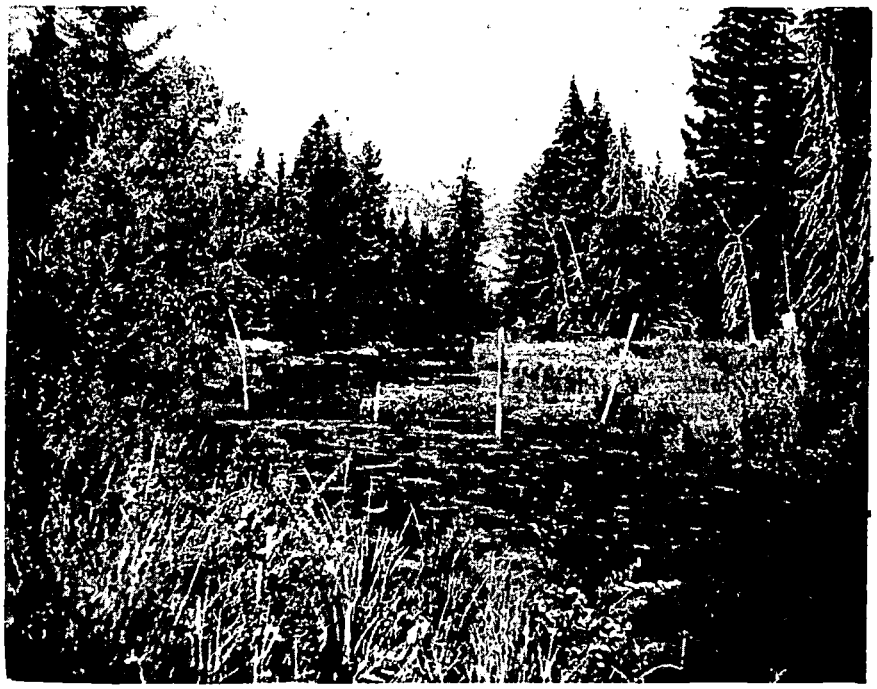


Figure 8. The Upstream Section of Bar BC Spring Creek.

METHODS

Methods for Physical and Chemical Data

Water samples were taken from Fish Creek, Blue Crane Creek, Spring Creek and the Snake River in August 1964, and from Bar BC Spring Creek in January of 1967. A chemical analysis of these samples was done by personnel of the Wyoming Game and Fish Department's Water Pollution Laboratory at Lander, Wyoming. Field determinations of dissolved oxygen were run with a Hach water chemistry kit. All dissolved oxygen values were at or near saturation values.

Taylor maximum-minimum recording thermometers were installed at the trap sites in all three creeks and in the Gros Ventre River above the mouth of Bar BC Spring Creek. There were read at least weekly. A Taylor Instrument Company 30 day temperature recorder was installed in the Snake River from March 6 to July 3, 1965. Air temperature records were obtained from U. S. Weather Bureau records for the years 1964 through 1966. These temperatures were measured at the U. S. Forest Service Office in Jackson, Wyoming.

Records of daily stream flows for the Snake River were obtained from the 1964 and 1965 "Surface Water Records for Wyoming" published by the United States Geological Survey. The records used are those for gaging station number 13-0225 located near Alpine, Wyoming. The 1966 water flow data were obtained from field sheets supplied by the District Engineer, Surface Water Branch, United States Geological Survey, Cheyenne, Wyoming.

Methods for Spawning and Migration Observations

Fish traps were constructed in Fish Creek and Bar BC Spring Creek during September and October of 1964. These traps were operated in 1965

and 1966. An existing fish trap located in the fish ladder at the mouth of Blue Crane Creek was operated until June 18, 1965. Information obtained from 1962 through 1964 at this trap was also used in this study.

The traps were designed to capture fish moving both upstream and downstream. There were two traps in the Blue Crane Creek fish ladder--an overpour trap in the upstream end and a wooden wier "V" trap in the downstream end. The Fish Creek and Bar BC Spring Creek traps were double wier types designed to capture fish moving either direction in "V" trapping boxes. It soon became apparent that this latter type would not effectively trap fish moving downstream. A considerable amount of time and effort was spent modifying these traps to improve their efficiency. A more complete discussion of the construction and operation of the fish traps is included in Appendix 1, Fish Division Administrative Report No. 0164-12-6701.

All mature cutthroat trout taken in the traps were weighed to the nearest 0.01 pound and measured to the nearest 0.1 inch (total length). Most were tagged with circular metal jaw tags and released. Scale samples were also taken from most cutthroat spawners. All young cutthroat trout taken in the traps were counted and measured. Scale samples were taken from some of these young trout and some were tagged. At Blue Crane Creek, the right pelvic fin was clipped from those cutthroat too small to be tagged. The left pelvic fin was clipped on small cutthroat trapped in Fish Creek.

Records werekept of all fish checked through the fish traps. Separate records were also kept of cutthroat tagged in the fish traps and subsequently caught by anglers in the Snake River. Fry traps were placed in Blue Crane Creek, Spring Creek, and Bar BC Spring Creek to obtain information on the timing of the downstream drift of cutthroat fry and fingerlings. These were downstream drift traps consisting of a "V" shaped net leading into a wooden holding box. On three occasions, cutthroat trout caught in the Snake River by

angling were tagged and released to obtain information on their movement into tributary streams.

Methods for Fecundity Analysis

Thirteen female cutthroat trout spawners were taken from the trap in Bar BC Spring Creek and killed. Three other female cutthroat were similarly killed from Blue Crane Creek. The ovaries from these fish were removed and preserved in ten percent formalin. The number of eggs per ounce from each female cutthroat was determined in a Von Beyer egg counting trough. This number multiplied by the total number of ounces of eggs taken from each female gave an estimate of the total number of eggs in each female.

Methods for Egg Mortality Studies

Weekly maps were made of the number and distribution of cutthroat trout redds during the 1965 and 1966 Bar BC Spring Creek spawning runs. Five redds were excavated in 1965 and 15 were excavated in 1966. A three by five foot fine-mesh net was staked in the creek below each redd to be excavated. The redd was slowly excavated by working the gravel downstream into the net. The net was then removed from the creek and all trout eggs were hand picked out of it. The dead and live eggs were placed in separate bottles and preserved in ten percent formalin.

In 1965, some difficulty was encountered in obtaining adequate samples. Egg pockets were quite deep (6 to 8 inches) and excavation of the gravel by hand was quite tedious. In 1966, the design of the egg net was changed and all excavation was by shovel. Two four-foot iron rods (3/8 inches diameter) were used to support the sides of the net and a short length of chain was sewed into the bottom of the net to prevent any material from washing under it. With these modifications in the net, it was possible to obtain good egg samples.

Total counts were made of all the eggs obtained from each redd and the percent of dead eggs was determined for each sample. For purposes of calculating the average egg mortality, only those samples containing at least 100 eggs were used.

Methods for Population Estimates

Estimates of cutthroat trout populations were made in 1964, 1965, and 1966 in sections of Fish Creek and Bar BC Spring Creek. These estimates were obtained by electro-fishing three times through a designated section of the stream. The stream sections used were of variable length. All fish captured during any one run were kept in a separate live car. The fish captured in each run were counted and measured for total length. Upon completion of the third run, all fish were released.

Stream sections were selected that were typical of the whole creek. To minimize escapement from and movement into the study areas, sections were selected which had a shallow riffle at each end. Two sections were electrofished in both Fish Creek and Bar BC Spring Creek in 1964 and 1965. In 1966, one section in Fish Creek and two in Bar BC Spring Creek were electrofished. A Homelite 1500 watt alternating current generator (Model 35A1-15-1) was used as a power source. The alternating current was converted to pulsed direct current with a variable voltage pulsator manufactured by the Pikes Peak Electronics Corporation. In order to adequately cover the width of Fish Creek, it was necessary to use two generators, two pulsators, and six electrodes. In 1964, one generator, one pulsator, and three electrodes were used in Bar BC Spring Creek, and in 1965 and 1966, two generators, two pulsators and four electrodes were utilized.

Each section was shocked slowly and thoroughly on each run. Small species of fish such as sculpin, dace, shiners, and young-of-the-year trout were not

affected by the electric field as much as were larger fish. These small fish were usually found in heavy cover or under the stream bank and considerable care and thoroughness was required to capture them.

Estimates of the total number of each species in a stream section were calculated by the Leslie method using a least squares line as described by Ricker (1958, p. 147 and 148). The numbers thus obtained for a stream section were expanded to estimates of the total fish population. The calculations and assumptions used to obtain these expanded estimates are discussed in the section on population estimates.

Estimates of the total fish population were made only in Bar BC Spring Creek. Because of the size of the stream and complexity of habitat in Fish Creek, no attempt was made to estimate the total fish population. It was felt that any such attempt would be grossly inaccurate as little was known of the relative extent and distribution of different types of habitat for young-of-the-year trout in Fish Creek.

Methods for the Age-Growth Study

One-hundred and sixty-seven scale samples were taken from cutthroat trout in Blue Crane Creek, 86 from cutthroat in Bar BC Spring Creek and 94 from those in Fish Creek. These samples were collected during the last half of 1964 and the first six months of 1965. All samples were taken from the left side of each fish between the lateral line and the anterior part of the dorsal fin. Samples were obtained from most migrant cutthroat spawners trapped in Fish Creek and Bar BC Spring Creek. Very few smaller cutthroat were trapped in these two creeks during this time and few scale samples were obtained from younger trout. A more representative sample was obtained at Blue Crane Creek where a large number of younger cutthroat were trapped.

Several scales from each sample were cleaned and mounted in water on a microscope slide. An image of these scales was projected to a diameter of 72.5X by means of a slide projector equipped with a microscope slide attachment. The best scale image was projected on a sheet of wet-process negative photocopy paper. The exposed image on the negative was transferred to a sheet of positive photocopy paper in a developer solution. By this method, direct images of scales could be obtained in a few minutes. A complete discussion of this method is found in Appendix 2, Fish Division Administrative Report number 0164-17-6702.

The age of each fish was determined from the scale images. Each scale image that could be aged was measured to the nearest 0.02 inch from the focus to each annulus and to the margin. The body length-scale length relationship was assumed to be a straight line described by the equation $L = a + bS$. The values for a and b were calculated by the least squares methods. The average length of the fish in each classes was then back-calculated.

RESULTS

Physical and Chemical Data

Water samples were obtained from the Snake River and the study tributaries on August 10, 1964. The chemical analyses of these samples were made at the Wyoming Game and Fish Water Pollution Laboratory in Lander, Wyoming. The results of the analysis of the Bar BC Spring Creek sample taken in August were misplaced, so another sample was taken and analyzed in January 1967. Copper, iron, and nitrogen were not measured because of improper preparation of the sample in the field. No programmed water chemistry to show seasonal changes was attempted in this study. Table I shows the results of the analyses.

The bicarbonate alkalinity in all four tributaries was greater than that in the Snake River. This may be due to the influence of spring water which contributes a major portion of the total flow in all tributaries. Other anions were comparable except for sulfate in the Fish Creek sample. The reason for this low concentration (1.5 ppm) is not known. The content of total cations (Ca, Mg, Na, and K) averaged 83.5 ppm in the four tributaries as compared with 57.7 ppm in the Snake River. Ground water may have caused increased salinities in the four spring-fed tributaries.

Figures 9, 10, 11, 12 and 13 show the mean water temperatures recorded in the study area. Water temperatures were least variable in Bar BC Spring Creek. The recorded extremes were 54 and 42 degrees Fahrenheit in this creek while they were 66 and 32 in Blue Crane Creek and 62 and 33 in Fish Creek. Winter water temperatures in the Gros Ventre and Snake Rivers were lower than those in the tributary streams. During periods of cold weather, anchor ice usually formed in both rivers while none was observed in the study tributaries. The mean water temperatures for Blue Crane Creek, Fish

Creek, and Bar BC Spring Creek in different years during cutthroat trout spawning runs were averaged and are shown in Table 2.

Volume Flows

Volume flows were measured in each tributary in August 1964. No other measurements of flow were made in these streams during this study. Flow data for the Snake River were obtained from United States Geological Survey surface water records. No measurement of the volume flow was made in the Gros Ventre River during the study. The estimated flow in this river varied from 7,000 to 8,000 cfs during the spring run-off to less than 200 cfs in the late summer. Irrigation diversions caused dewatering of many parts of the lower three miles of the Gros Ventre River.

Volume flows in the Snake River for 1964, 1965, and 1966 are illustrated in Figure 14. This figure shows the different water conditions encountered during the study. The 1964 average total precipitation was 24.48 inches for the Snake River drainage which was 1.55 inches more than the 1931 to 1965 average. The 1965 run-off was heavier than average because of this and also extended late into the summer due to cold weather through May and heavy precipitation in June. The average total precipitation in both 1965 and 1966 was less than the 35-year average and the 1966 run-off was lower than normal. The sharp increase in river flow in December 1964 was due to rain in the study area which melted most of the snow cover and washed out all the fish traps.

Weather Data

Weather data collected at Jackson, Wyoming for 1964, 1965, and 1966 were obtained from U. S. Weather Bureau Climatological Records. The data are summarized in Figure 15 and 16. Figure 15 illustrates that the mean

TABLE I

Water Chemistry Data for the Snake River and the Study Tributaries

	Snake River	Blue Crane Creek	Spring Creek	Fish Creek	Bar BC Spring Creek
pH	8.5	8.2	8.2	8.8	8.4
Alkalinity MO	94.0	130.0	176.0	126.0	185.0
phth	4.0	0.0	0.0	0.0	0.0
Ortho-phosphates	0.05	0.024	0.076	0.014	0.05
Dissolved Solids	134.0	182.0	250.0	178.0	258.0
Chloride	3.5	3.0	3.0	5.0	4.2
Carbon Dioxide	0.0	1.0	1.0	0.0	0.0
Turbidity	0.0	0.0	0.0	0.0	0.0
Sulfide	0.0	0.0	0.0	0.0	0.0
Nitrogen NH_3	0.0040	0.0052	0.0052	0.0046	-
NO_3	0.020	0.016	0.020	0.036	-
NO_2	0.093	0.092	0.104	0.105	-
Sulfate	42.8	21.0	42.8	1.5	59.2
Calcium	30.4	40.0	38.4	33.6	57.6
Magnesium	3.9	13.6	28.1	18.4	16.6
Sodium	21.4	29.3	16.0	15.0	9.5
Potassium	2.0	3.2	6.2	6.4	2.0
Copper	0.0	0.0	0.0	0.0	-
Iron	0.0	0.0	0.0	0.0	-

Fig. 9. Blue Crane Creek Mean Water Temperatures

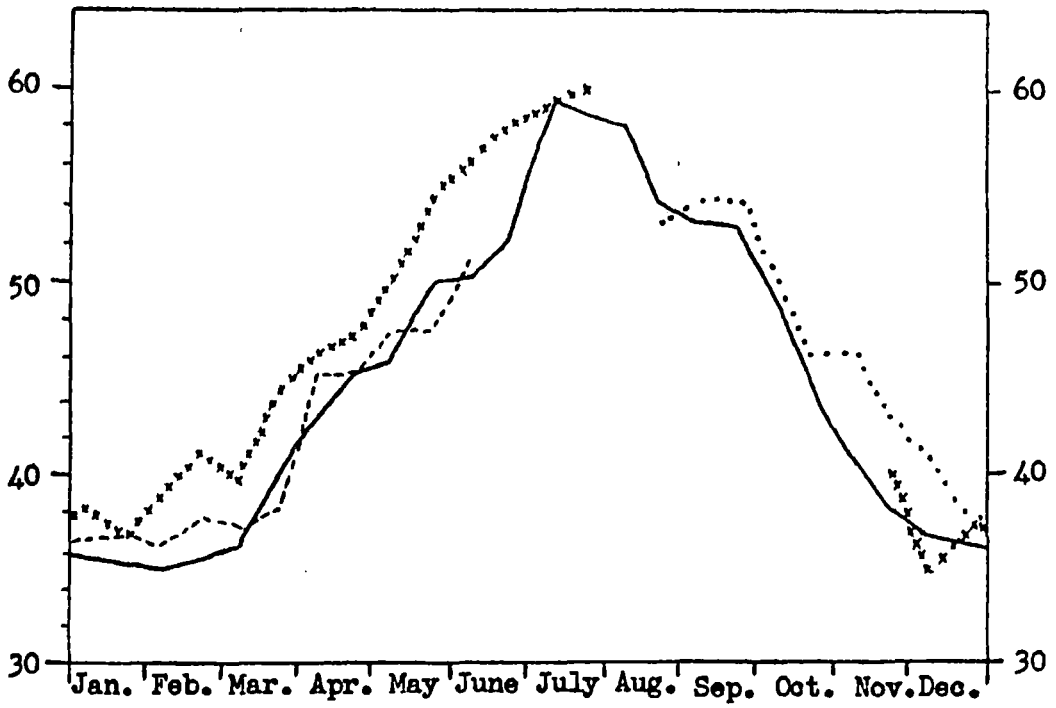


Fig. 10. Fish Creek Mean Water Temperatures

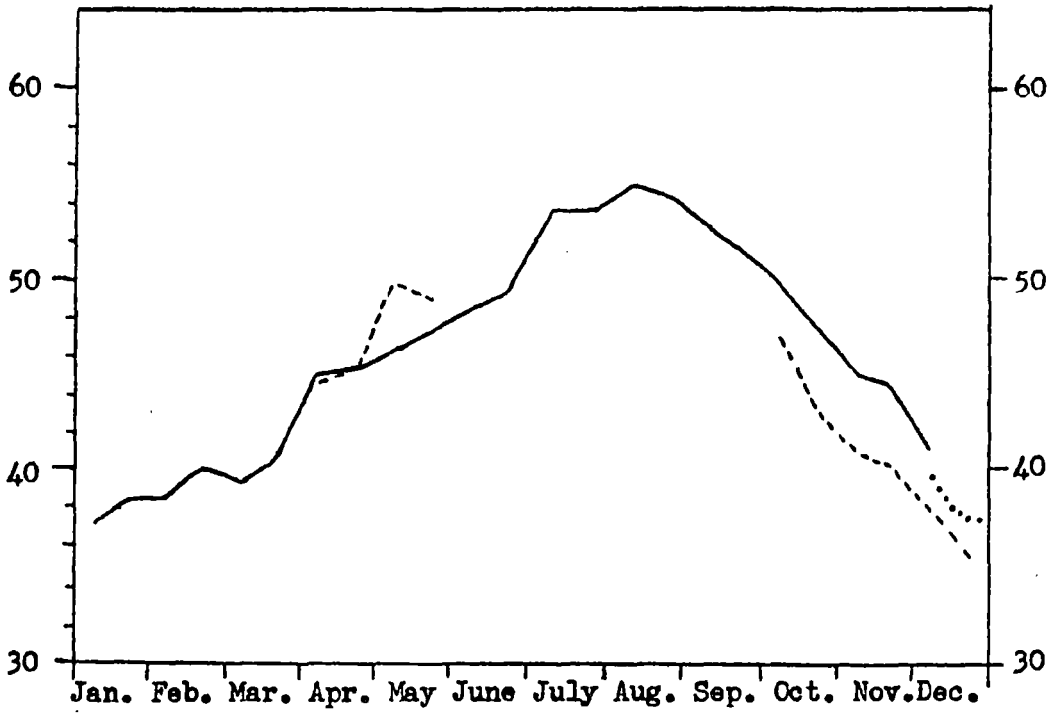


Fig. 11. Bar BC Spring Creek Mean Water Temperatures

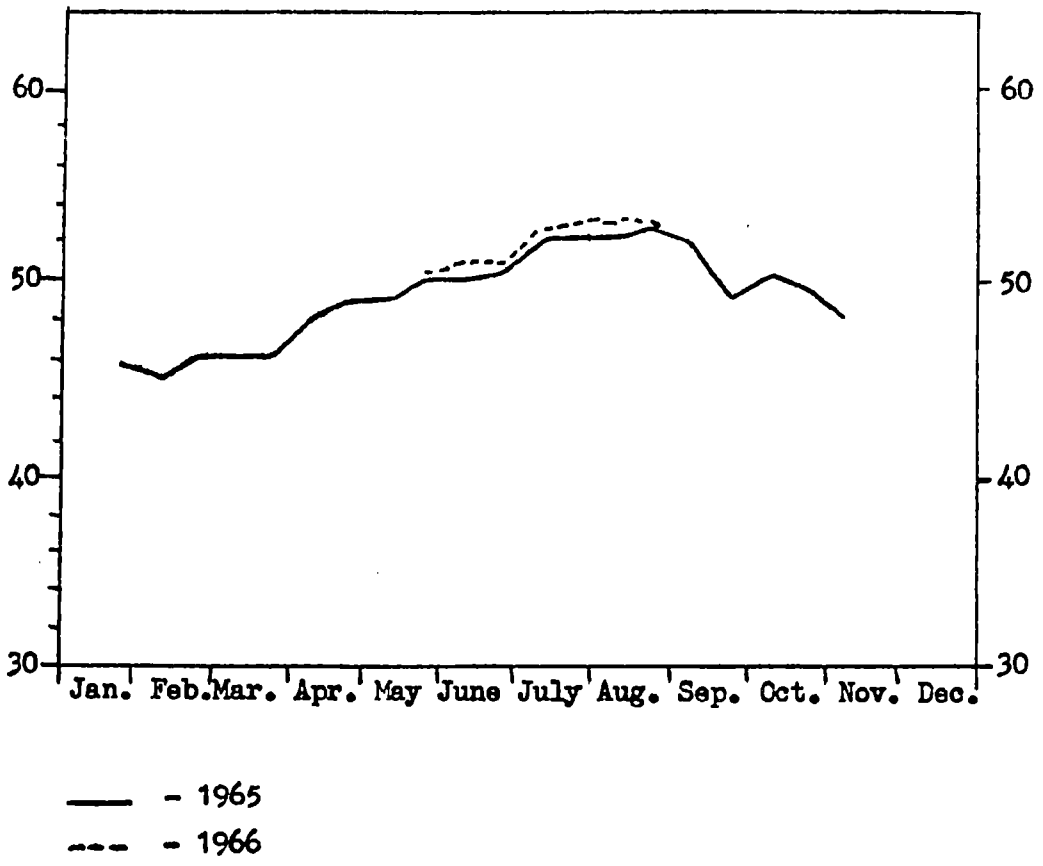


Fig. 12. Snake River Mean Water Temperature

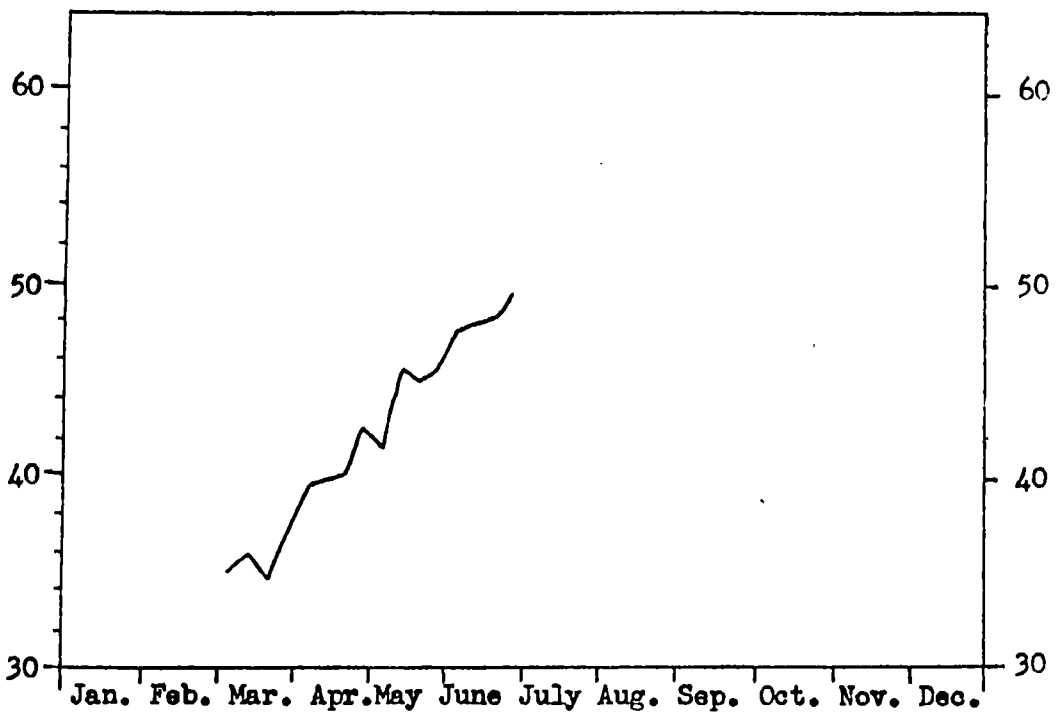


Fig. 13. Gros Ventre River Mean Water Temperature

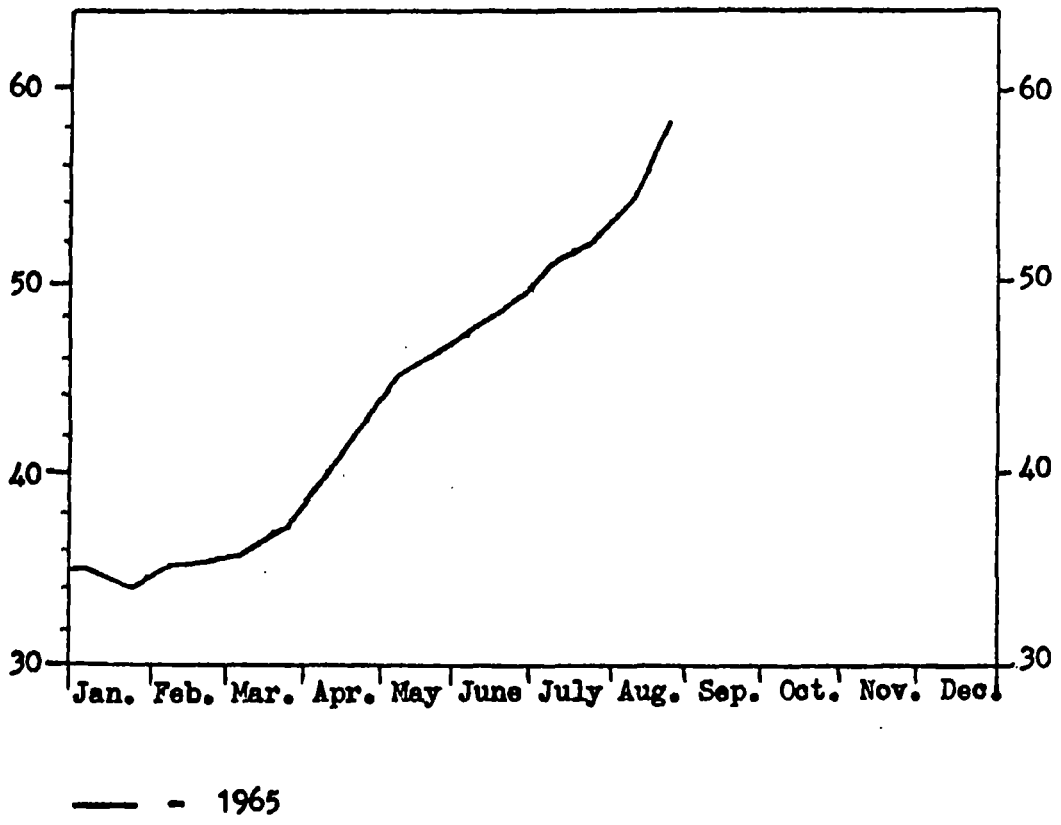


TABLE 2

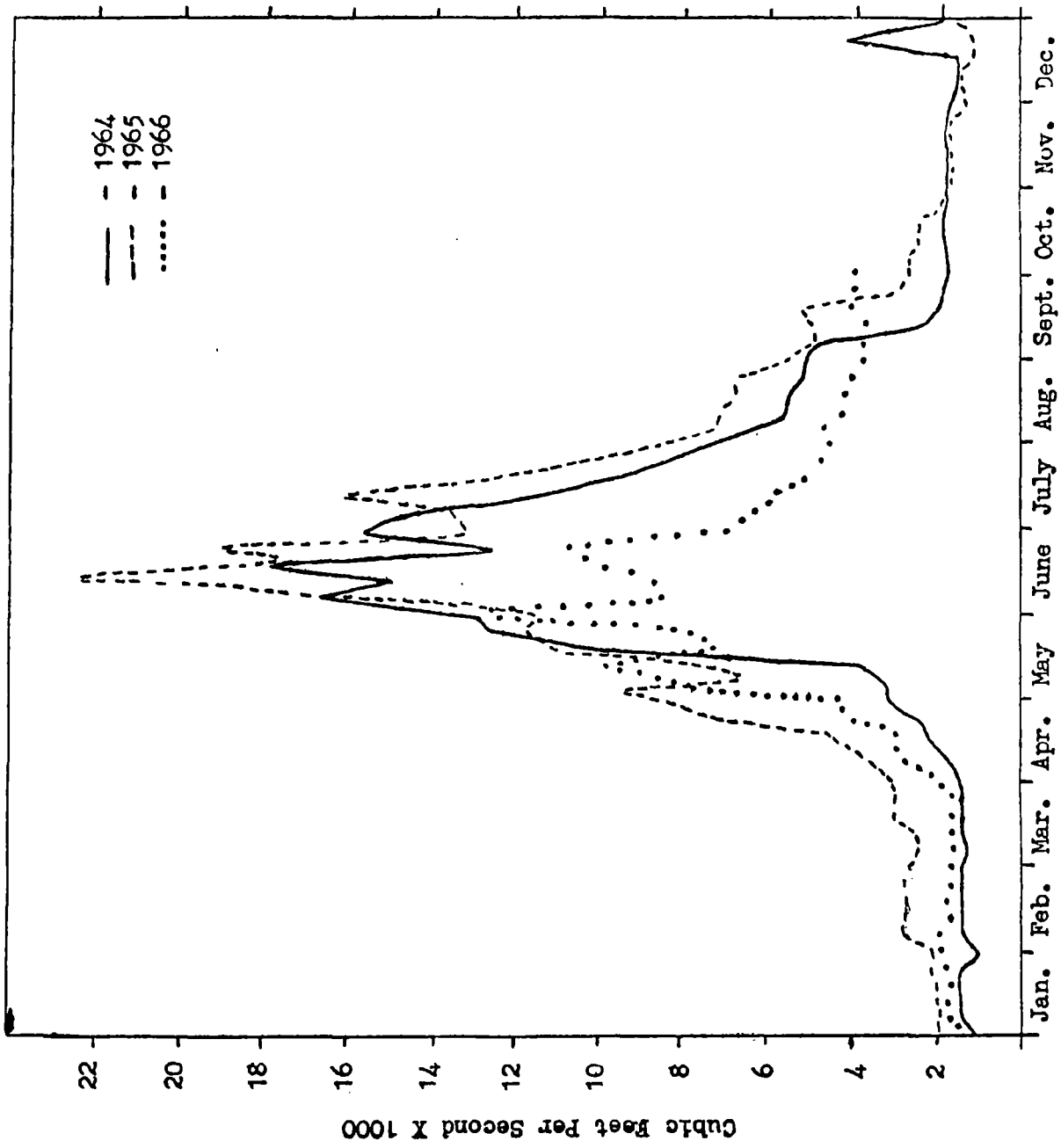
Mean Water Temperatures in the Study Area
During Cutthroat Trout Spawning Runs

Time Period	3-16 to 3-31	4-1 to 4-15	4-16 to 4-30	5-1 to 5-15	5-16 to 5-31	6-1 to 6-15	6-16 to 6-30	7-1 to 7-15
Blue Crane Creek*	(40.5	44.7	46.3	47.5)**	51.8	52.7	55.0	58.5
Fish Creek*	40.5	44.7	(45.5	48.0	48.2	48.5)	49.5	53.5
Bar BC Spring Creek*	46.0	48.0	49.0	49.0	(50.2	50.5	50.7	52.7)
Snake River	33.5	39.5	41.2	43.5	45.7	47.7	49.0	-
Gros Ventre River	37.0	39.5	42.0	45.0	46.0	47.5	49.0	51.0

* Mean for all years of data

** Area in parentheses indicates time of cutthroat spawning run

Fig. 14. Snake River Volume Flows
(at gaging station number 13-0225)



temperatures in January and February of 1964 were colder than those in 1965. Figure 16 shows the large amount of precipitation received during the winter of 1964-1965.

Timing and Duration of the Cutthroat Trout Spawning Runs

Observations of the 1963, 1964, and 1965 cutthroat trout spawning runs were made at Blue Crane Creek and at the Blue Crane trap. Stream and trap observations were made in 1965 at Fish Creek and in 1965 and 1966 at Bar BC Spring Creek. A summary of the timing of these spawning runs through fish traps is presented in Table 3. Figures 17, 18, and 19 also indicate the timing and peak of the spawning runs through the fish traps.

Although not clearly indicated by the trap records, the peak of the cutthroat trout spawning run in Blue Crane Creek occurred in April. Observations of spawning activity (i.e. redd counts and direct counts of cutthroat spawners) in Blue Crane Creek and Spring Creek strongly suggested this. In mapping redd distribution in these two creeks in 1965, it was determined that about 70 percent of the total number of redds present on May 27 had been made prior to April 26.

In Fish Creek, most migrant spawners entered the trap in late April and early May. Only one cutthroat redd was found in mid-April of 1965 when maps were made of spawning areas downstream from the fish trap. According to records of a fish trap operated in 1957 and 1958, the cutthroat spawning occurred April 17 to May 29 in 1957, and May 2 to May 19 in 1958. This trap was located about one-half mile upstream from the present trap and was operated to obtain wild cutthroat trout eggs. All fish trap records indicated that the cutthroat spawning run was still in progress in late May and early June when high water forced removal of the fish traps. Because the size of the cutthroat fry in Fish Creek was similar to that of Bar BC Spring Creek fry, it is felt

Fig. 15. Mean Air Temperature as a Departure from the 1931 - 1965 Average

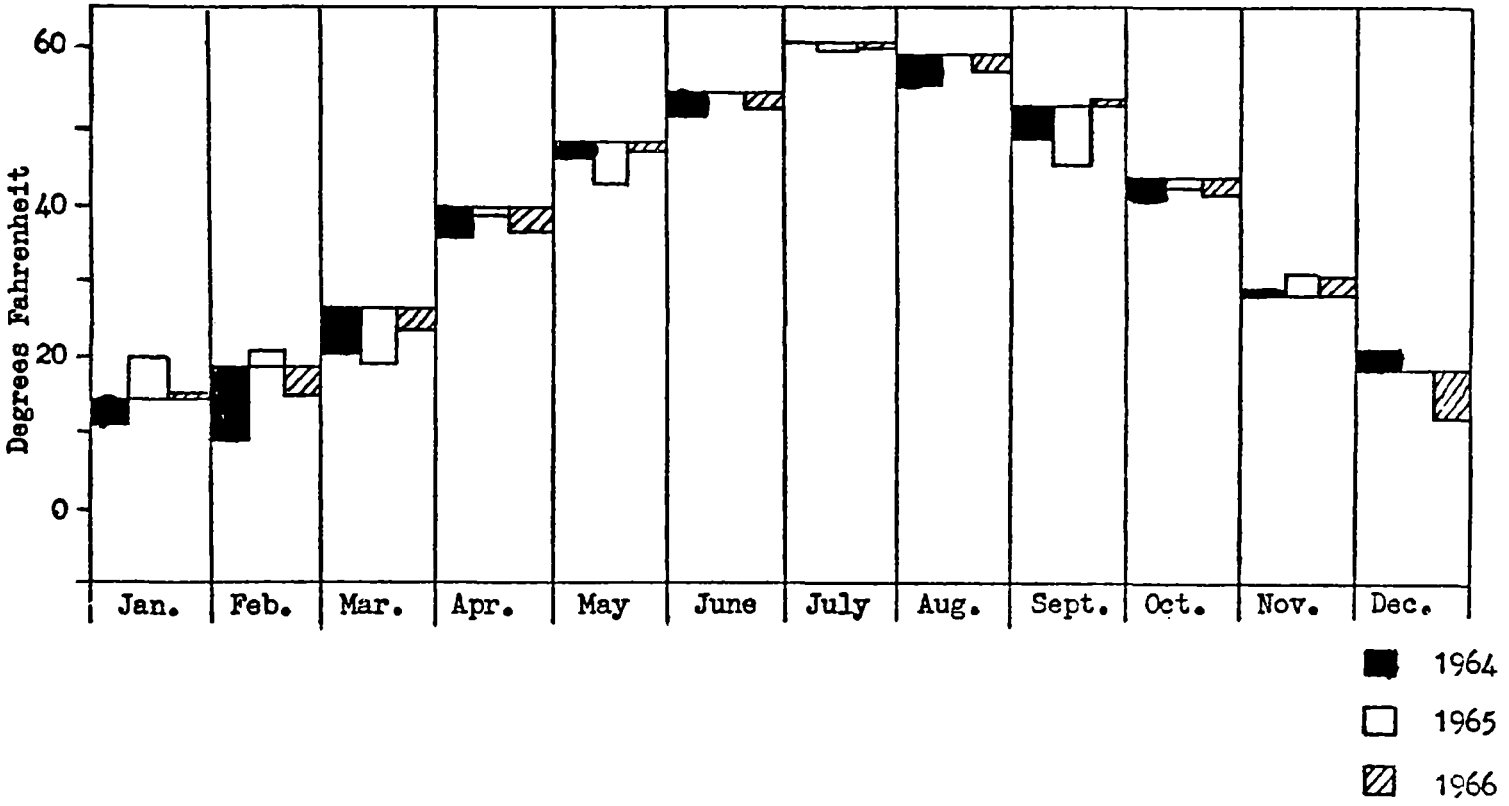
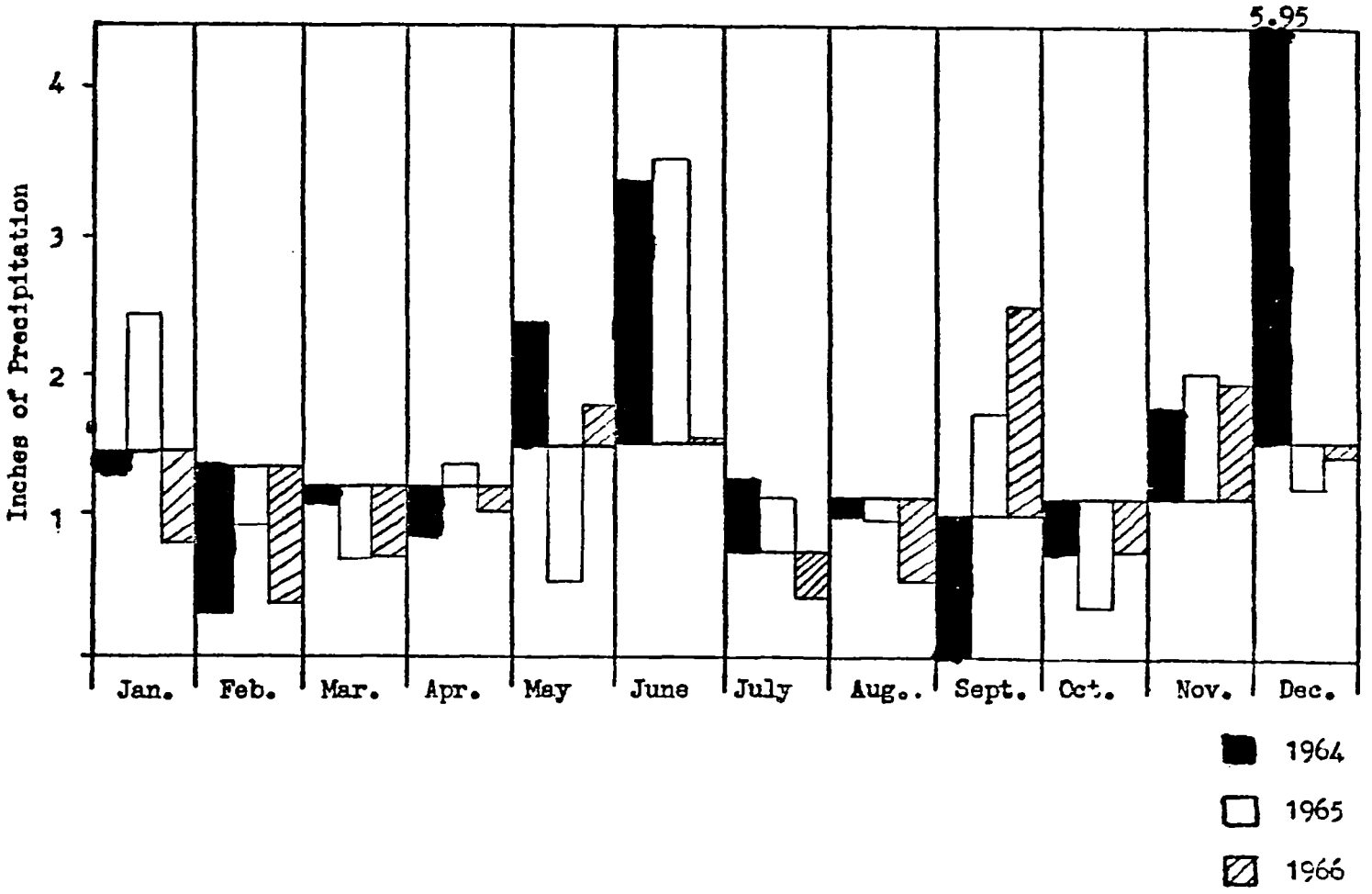


Fig. 16. Monthly Precipitation as a Departure from the 1931 - 1965 Average



that considerable spawning occurred during the early part of the annual run-off after the traps were removed.

The best information was obtained from Bar BC Spring Creek where the entire 1965 and 1966 spawning runs were trapped. The major portion of the spawning run occurred in June of both these years. Tagging records from a fish trap operated here in 1953 to obtain wild cutthroat trout eggs indicated that the spawning run lasted from June 4 to July 1 of that year. This trap was located about 50 feet downstream from the present trap. According to field observation by area fisheries management personnel, cutthroat trout were spawning in Bar BC Spring Creek in June 26, 1952, June 18, 1956, June 15, 1962 and June 21, 1963.

Simon (1946) stated that the cutthroat trout begin to spawn in small spring-fed Snake River tributaries in mid-March. He further reported that Yellowstone Lake cutthroat trout spawn in tributary streams in May, June and July and that the time of spawning depends on the altitude and the consequent differences in water temperature. The differences in the timing of the spawning runs in the three tributaries studied cannot be accounted for by temperature characteristics alone. Average water temperatures in Bar BC Spring Creek in March and April were higher than those in the other two creeks although the spawning run occurred much later. Although the March and April temperature data for Blue Crane Creek and Fish Creek were quite similar, the Blue Crane spawning run began several weeks earlier. The mean water temperatures in all three tributaries were at least five degrees above the winter minimum temperatures before the cutthroat spawning runs began.

Differences in the timing of cutthroat spawning migrations in several Yellowstone Lake tributaries were described by Cope (1957b). He reported that temperature characteristics of these streams correlated somewhat with

the timing of the migrations, but also presented evidence that the differences in timing may be due to genetic factors. Some observations made during this study suggested that some genetic differences may exist between cutthroat trout spawners in Bar BC Spring Creek and those in Blue Crane and Fish Creeks. Many of the Bar BC cutthroat spawners were very dark colored and their pelvic and pectoral fins were purple. Many of the cutthroat fingerlings observed in Bar BC Spring Creek were similarly colored. Cutthroat trout in the other two creeks were typically lighter in color and their paired fins were uniformly dark brown. If these differences in coloration actually reflect genetic diversity, then the later maturation of cutthroat spawners that migrate into Bar BC Spring Creek could also be due to genetic factors.

TABLE 3

The Timing of Cutthroat Trout Spawning Runs Through Fish Traps in Three Snake River Tributaries

		1963	1964	1965
Blue Crane Creek	Earliest observed Spawners	3-2	3-17	2-19
	Latest observed Spawners	7-1	7-13	5-31[1]
	Total number of Spawners	38	31	34
	Peak period of spawning run	4-26 to 5-20	4-11 to 5-11	4-19 to 5-6

		1957	1958	1965	1966
Fish Creek	Earliest observed Spawners	3-20	4-8	3-17	4-7[2]
	Latest observed Spawners	5-29[3]	5-19[3]	6-4[3]	5-27[3]
	Total number of Spawners	165	69	67	11
	Peak period of spawning run	4-17 to 5-29	5-2 to 5-15	4-30 to 6-4	5-2 to 5-7[4]

		1953[5]	1965	1966
Bar BC Spring Creek	Earliest observed Spawners	6-3	4-10	5-28[6]
	Latest observed Spawners	7-4	8-5	7-25
	Total number of Spawners	92	227	128
	Peak period of spawning run	6-8 to 6-29	6-14 to 7-5	6-14 to 6-30

1 - Trap removed on 6-10-65
2 - Trap installed 4-6-66
3 - Trap removed the following day
4 - Trap removed for two weeks after 5-7-66
5 - Data from fish tagging records
6 - Trap installed 5-26-66

Fig. 17. Cutthroat Trout Spawning Runs Through the Blue Crane Creek Trap

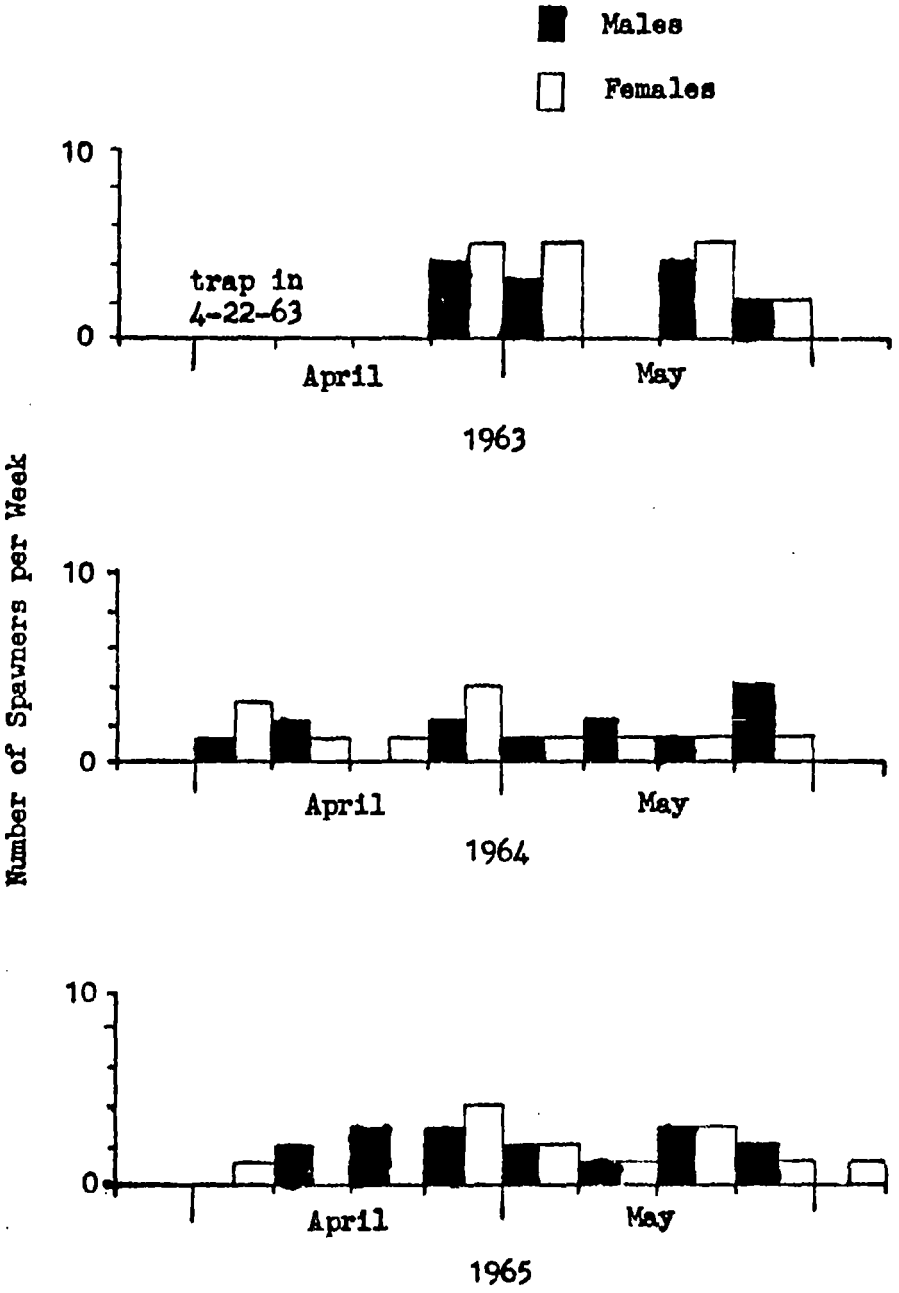


Fig. 18. Cutthroat Trout Spawning Runs Through the Fish Creek Traps

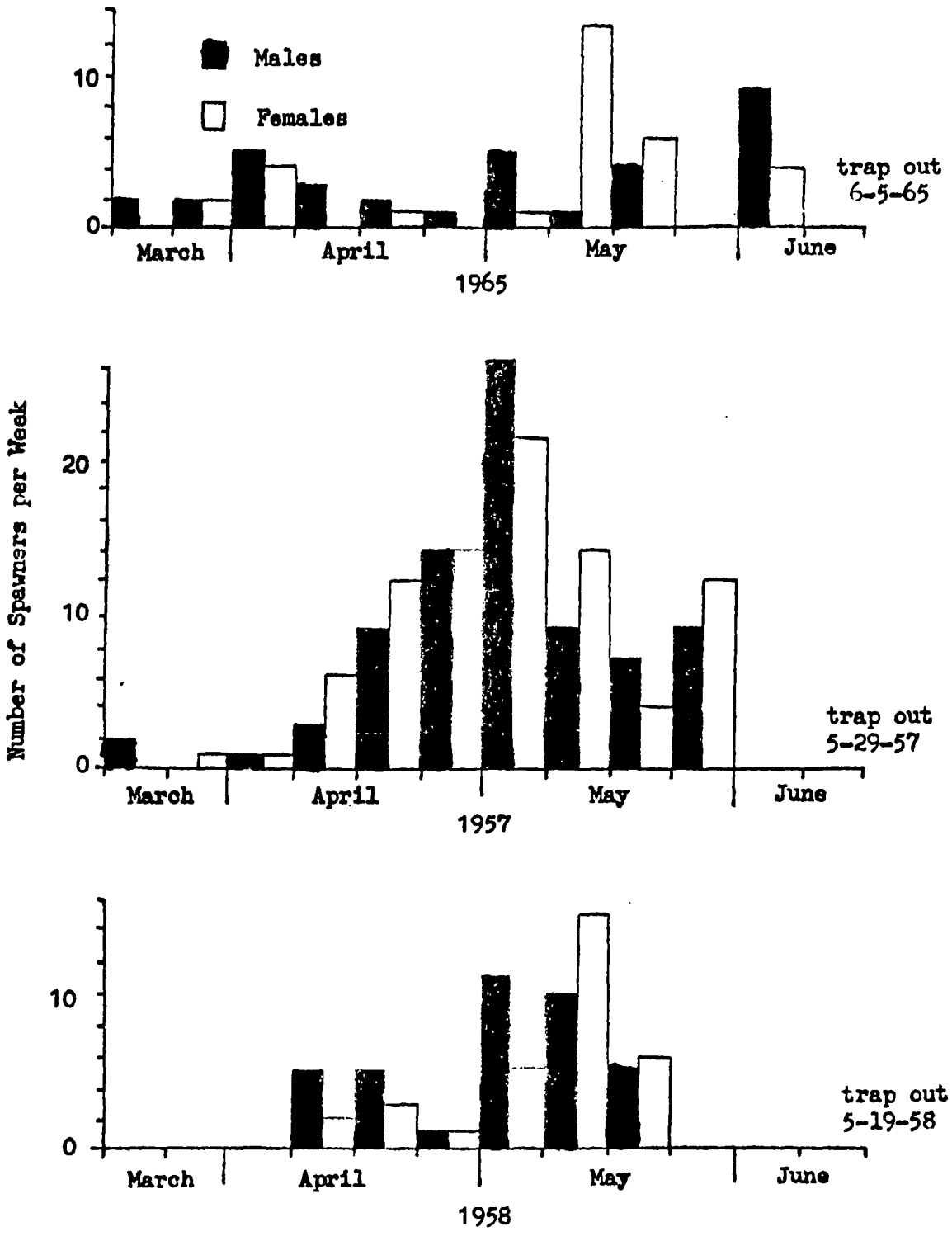
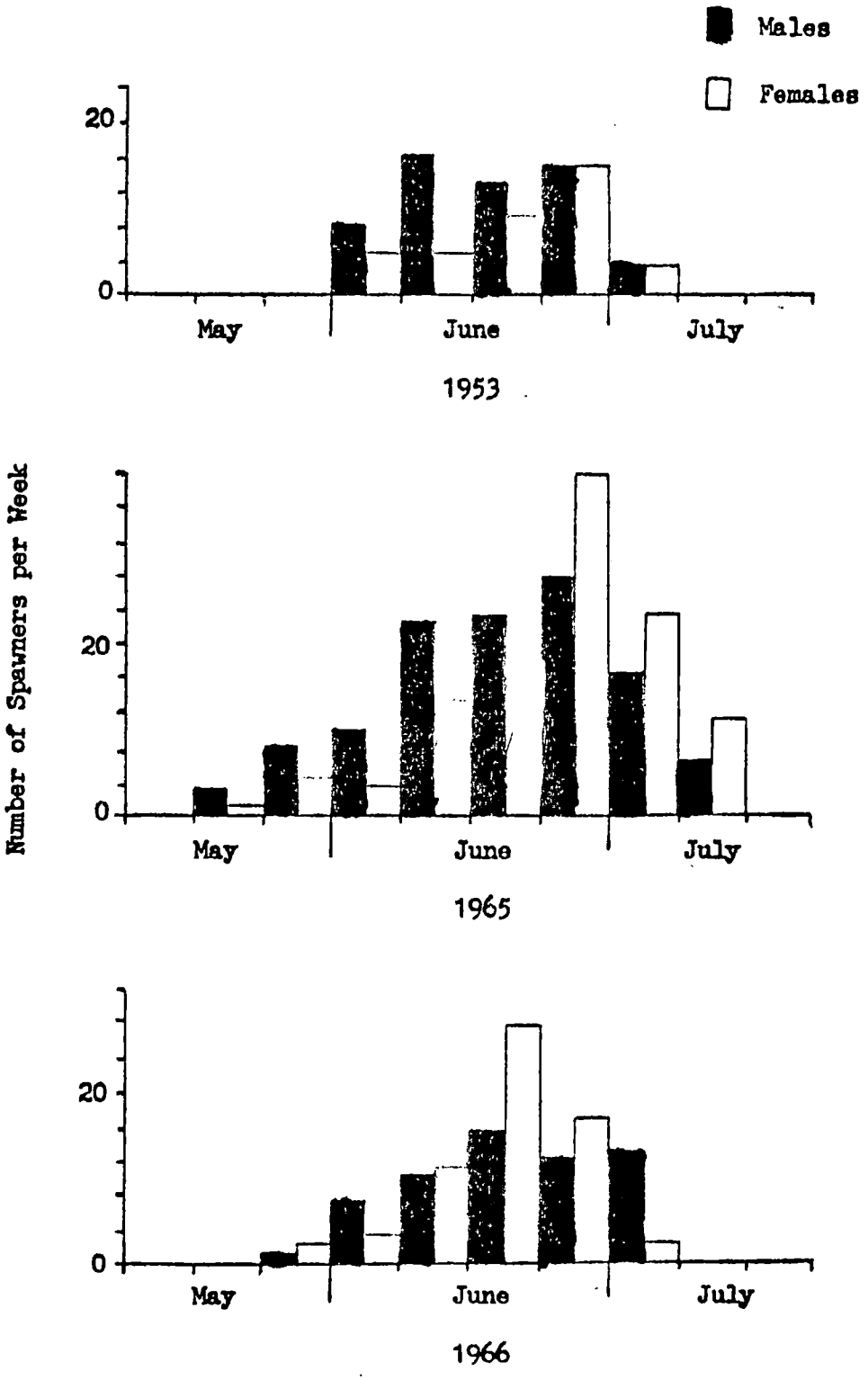


Fig. 19. Cutthroat Trout Spawning Runs Through the Ear EC Spring Creek Traps



Choice of Spawning Areas

All three tributary streams investigated in this study contained extensive areas of suitable spawning gravel. The distribution of the best gravel and the presence of barriers accounted for the distribution of cutthroat redds in Yellowstone Lake tributary streams according to Cope (1957a). He further reported that cutthroat trout seem to prefer stream bottoms with particles from three-fourths to three inches in diameter. Most of the cutthroat redds observed in this study were found in areas where the gravel size varied from one to two and one-half inches, but considerable spawning occurred in one area of Bar BC Spring Creek containing gravel from one-half to one inch in diameter.

A typical redd was usually constructed in suitable gravel near the creek bank or midstream below a bend in the stream where the current was reduced. Several redds were found in riffle areas with bottom material up to eight inches in diameter and one redd was found at the site of an old beaver dam. Considerable silt and detritus had invaded this latter redd and excavation revealed a very high egg mortality. Egg pockets were usually covered by six or eight inches of gravel and two or more egg pockets were usually to be found in a redd.

Many areas of suitable spawning gravel were not utilized by cutthroat. The obvious reason for this is the fact that the number of spawners was not large in any of the creeks. Superimposition of redds was observed in the area where Blue Crane Creek and Spring Creek join. Large numbers of cutthroat spawning here had created a hole several feet deep and about eight feet in diameter while moving an estimated two cubic yards of gravel downstream a short distance. Further evidence of superimposition was observed in Bar BC Spring Creek where excavation of a single redd uncovered pre-eyed eggs, eyed eggs and alevin.

Barriers to cutthroat trout migration were also observed to limit spawning areas. A beaver dam blocking the upstream portion of Blue Crane Creek was removed in 1964. Only four redds had been observed above this dam in 1963. In 1965, 16 redds were found in the same area. Observations of redd distribution made in Blue Crane Creek and Spring Creek in 1965 revealed that late-spawning cutthroat utilized the lower portions of these two creeks. Most of the redds found in the upstream portions of these creeks had been constucted early in the spawning season. Similar observations made in Bar BC Spring Creek in 1965 and 1966 indicated a more random distribution of late-spawning cutthroat redds. Cope (1957a) stated that, with one exception, late-spawning cutthroat utilized the downstream portions of several Yellowstone Lake tributaries.

Numbers of Cutthroat Trout Spawning

The number of cutthroat trout spawners trapped in the three creeks for different years is shown in Table 3. Reliable information on the total number of cutthroat trout spawners was obtained only at Bar BC Spring Creek for 1965 and 1966. The entire spawning runs were trapped in these two years, the number of resident cutthroat spawners was known and an estimate of the number of cutthroat trout that spawned downstream from the fish trap was made.

The resident cutthroat trout population in Bar BC Spring Creek was composed almost entirely of immature fish. During the winter of 1964-1965, only three large resident cutthroat were observed in the creek. Several jaw-tagged cutthroat trout were captured during electro-fishing operations in October of 1965 and 1966 and it is probable that these were residents for at least part of the winter. Estimates of the number of cutthroat trout spawning downstream from the Bar BC Spring Creek trap were made from redd counts. It was observed that each female cutthroat dug two or three redds. On this basis, it was estimated that seven female cutthroat in 1965 and eight in 1966 spawned below the fish trap.

No quantitative information was obtained on the size of the resident cutthroat trout population in Blue Crane Creek and Spring Creek. Considerable numbers of large cutthroat were observed in these two creeks during the fall and winter and it is felt that resident cutthroat trout spawning in these creeks probably contributed a large but unknown proportion of the total spawning fish.

Prior to 1956, large numbers of cutthroat trout reportedly migrated into Blue Crane Creek to spawn. In 1956, the mouth of the creek was cut off by the construction of a dam and headgate, and in 1961, a fish ladder was constructed to re-establish the cutthroat spawning run. It is apparent from the trap records that a well-defined cutthroat spawning run has not yet been established. In 1963, more migrant cutthroat spawners (56) were trapped while moving downstream than were trapped moving upstream. Of the total number of upstream migrants in 1963, twelve (31.5%) had been previously tagged. These trout were mature spawners that had been captured in the downstream trap, tagged, and released downstream. They then spent from one week to two months in the Snake River and migrated back into Blue Crane Creek. Most of these trout were in pre-spawning condition when they were captured in the downstream trap and gravid when they were captured in the upstream trap. Several, however, were spawned out when they were captured in both traps. There was no indication that any of these trout spawned in the Snake River.

Records of tagged cutthroat spawners indicated that some movement also occurred through Spring Creek. In 1963, seven tagged migrants were recaptured in the traps that had moved either upstream or downstream through Spring Creek and the Snake River and back to Blue Crane Creek. Similar movements of tagged immature cutthroat were observed in 1963, 1964, and 1965. It is assumed that these movements of pre-spawning and post-spawning cutthroat were probably at random.

Little information was obtained on the size of the resident cutthroat population in Fish Creek. The number of cutthroat trout spawning downstream from the Fish Creek trap was not known. There was a total of 14,250 feet of creek below the trap and approximately 18 percent (2,600 feet) was excellent spawning area. Observations of spawning activity were not possible during May and June because of high water. As previously mentioned, cutthroat trout were still migrating up Fish Creek at the time high water forced removal of the traps and no information was obtained on the number of trout migrating after the traps were removed.

Sex Composition of the Spawning Runs

Table 4 indicated the sex ratio of cutthroat trout spawners trapped in the three tributaries for several years. Only eleven cutthroat spawners were trapped in Fish Creek in 1966, and the data for that year are not included. It is evident that the sex ratio did not differ significantly from 1:1. Irving (1954) also reported a 1:1 spawning ratio in cutthroat trout from Henry's Lake, Idaho. Snyder and Tanner (1960) reported changes in the sex ratio of cutthroat spawning runs in Trapper's Lake, Colorado from one male per 1.5 females in 1958 to one male per 3.1 females in 1959. They could not definitely establish the reasons for this shift in sex ratio, but suggested that fishing mortality favoring the females and removal of a large number of males for brood stock could have contributed.

Figures 17, 18 and 19 illustrate the numbers of males and females migrating into the fish traps during the spawning run for several years. In both Fish Creek and Bar BC Spring Creek there was an indication that females tended to migrate somewhat later than did the males. Snyder and Tanner (1960) observed no such tendency in the cutthroat trout in Trapper's Lake, Colorado, although Wyoming Game and Fish Department spawning crew personnel frequently observe this in their trapping operations.

TABLE 4

Sex Composition of Cutthroat Trout Spawning Runs
in Three Snake River Tributaries

Creek	Year	Number of Spawners	% Males	% Females	Ratio
Blue Crane Creek	1963	30	42.3	56.7	1:1.3
	1964	28	53.6	46.4	1:0.8
	1965	29	55.2	44.8	1:0.8
Fish Creek	1957	165	48.5	51.5	1:1.1
	1958	69	53.6	46.4	1:0.9
	1965	65	52.3	47.7	1:0.9
Bar BC Spring Creek	1953	92	59.8	40.2	1:0.7
	1965	226	50.9	49.1	1:1.0
	1966	121	47.9	52.1	1:1.1

Age Composition of the Spawning Runs

Information on the age composition of the 1965 cutthroat trout spawning runs was obtained during this study at Fish Creek and Bar BC Spring Creek. In 1958, the age of 45 cutthroat spawners from Fish Creek were determined by area fisheries management personnel. This information for these three spawning runs is presented in Table 5.

The data revealed that the majority of cutthroat trout spawning in these two creeks belonged to age classes III and IV. By averaging the two years of data from Fish Creek, 40.7 percent of the cutthroat spawners were age III and 48.5 percent were age IV for a total of 89.2 percent in these two age classes. In Bar BC Spring Creek, the proportion of age III to age IV cutthroat spawners was more nearly equal (43.3 percent and 41.1 percent respectively) for a total of 84.4 percent in these two age classes.

At Blue Lake, California, about 90 percent of the 1939 and 1940 cutthroat trout spawning runs belonged to age class IV, about eight percent were age V and about two percent were age III according to Calhoun (1944). Cutthroat trout in Trapper's Lake, Colorado appear to mature earlier than those in the Snake River according to Snyder and Tanner (1960). They reported that age class III predominated in the 1958 spawning run and age class II was second. In 1959, age class IV predominated, suggesting the presence of a dominant year class.

Table 6 indicates that percentage of each sex in each age class for the three spawning runs. The data from all three runs indicated that the majority of females were in age class IV. An average of 45.3 percent of Fish Creek cutthroat males were age III and 39.0 percent were age IV while 37.9 percent of Fish Creek females were age III and 55.2 percent were age IV.

The data suggested that many Snake River cutthroat females do not mature until age IV. Only one mature age II female was observed during this study, although a number of age II males were trapped. The data also suggested that most cutthroat males mature at age III. The oldest spawner observed in this study was an age VI cutthroat male. Several other large males were also trapped, but their scales were entirely regenerated and no determination of their age could be made. There is some indication that cutthroat males live longer than females. One male cutthroat from Fish Creek was aged at VIII by fishes management personnel.

TABLE 5

Age Composition of Cutthroat Trout Spawning Runs
Trapped in Two Snake River Tributary Streams

		Age Class									
		II		III		IV		V		VI	
		Number	%*	Number	%	Number	%	Number	%	Number	%
1958 Fish Creek	Males	1	2.2	8	17.8	6	13.3	1	2.2	0	-
	Females	0	-	11	24.4	16	35.6	2	4.5	0	-
	Total	1	2.2	19	42.2	22	48.9	3	6.7	0	-
1965	Males	0	-	11	19.6	11	19.6	5	8.9	0	-
	Females	0	-	11	19.6	16	28.6	2	3.6	0	-
	Total	0	-	22	39.2	27	48.2	7	12.5	0	-
Bar BC Spring Creek 1965	Males	4	4.4	26	28.9	15	16.7	1	1.1	1	1.1
	Females	1	1.1	13	14.4	22	24.4	7	7.8	0	1.1
	Total	5	5.6	39	43.3	37	41.1	8	8.9	1	1.1

* Percent of the total number of known-age spawners for any run

TABLE 6

Percent by Sex of Cutthroat Trout Spawners in Various Age
Groups Trapped in Two Snake River Tributary Streams

	Fish Creek				Bar BC Spring Creek	
	1958		1965		1965	
Age Group	percent males*	percent females	percent males	percent females	percent males	percent females
II	6.3	-	-	-	8.6	2.3
III	50.0	37.9	40.7	37.9	55.3	30.2
IV	37.4	55.2	40.7	55.2	31.9	51.2
V	6.3	6.9	18.6	6.9	2.1	16.3
VI	-	-	-	-	2.1	-

*Percent of the total number of known-age males or females for any spawning run

Post-Spawning Mortality of Cutthroat Trout

Information on post-spawning mortality of cutthroat trout was obtained at Bar BC Spring Creek in 1965 and 1966. A direct count method was used in 1966 to estimate the post-spawning mortality and an indirect method utilizing 1965 and 1966 data was used to obtain a similar estimate for 1965.

In 1966, 116 cutthroat spawners checked upstream through the fish trap were tagged or had been previously tagged. Of these, 22 were trapped again while migrating back to the river. On August 19, 1966, the lower 3,000 feet of Bar BC Spring Creek above the fish trap was electro-fished. It was assumed that very few cutthroat trout were above this portion of the creek. This assumption was based on close observations made in 1965 and 1966. Thirty-one tagged cutthroat post-spawners were captured during this operation and two escaped. Thirty of the captured cutthroat had migrated upstream through the fish trap in 1966 and one was a stream resident. The number of surviving post-spawners was estimated by adding the number migrating out of the creek and the number captured by electro-fishing for a total of 54. This number divided by the total number of tagged cutthroat released upstream in 1966 (116) gave an estimated of 46.5 percent survival of post-spawning cutthroat.

In 1965, 224 cutthroat spawners were tagged at the Bar BC Spring Creek fish trap. Twenty-one of these, two of which had recently lost their jaw tags, were trapped again as spawners in 1966. Of the 19 with tags, 5 had been checked downstream through the fish trap in 1965 and 14 had moved out of the creek sometime after the trap was removed. To estimate the total number of 1965 cutthroat post-spawners that migrated out of the creek,

it was assumed that the number of 1966 repeat cutthroat spawners checked downstream (5) was in the same proportion to the total number of post-spawners checked downstream in 1965 (32) as the total number of repeat spawners (19) was to the total number of post-spawners migrating downstream (5 : 32 = 19 : 122). This number divided by the total number of spawners released upstream in 1965 (122/224) gave an estimate of 54.4 percent survival of post-spawners in 1965. For the purposes of this calculation, the two repeat spawners that had lost their jaw tags were disregarded as it was not known whether they migrated downstream through the fish trap or after the trap was removed.

Survival of post-spawning cutthroat trout as considered here involved only survival while in the creek or until migration back into the river. Subsequent survival of these trout in the river was not known. In 1965, an estimated 102 cutthroat spawners died in the creek for a total mortality of 45.6 percent. Of these 102, 10 were caught by fishermen (9.8 percent), 34 were found dead in the creek (33.3 percent), and 58 cannot be accounted for (56.9 percent). In 1966, an estimated 62 cutthroat spawners died in the creek for a total mortality of 53.5 percent. Of these, 8 were caught by fishermen (12.9 percent), 13 were found dead in the creek (21.0 percent), and 41 cannot be accounted for (66.1 percent). These mortalities are similar to those reported by Hall and Cope (1961) who indicated that spawning mortality of adults was 48.1 percent in Yellowstone Lake tributaries.

Daily observations were made of much of the lower portion of the creek during and after the spawning runs in 1965 and 1966. Efforts were made to locate cutthroat spawners that died in the creek and record their tag numbers,

but relatively few were observed. It is possible that some dead spawners were overlooked, but those that were found were quite conspicuous. Dead spawners were found in the creek from one to 41 days after they had migrated through the fish trap. Most were observed from three to four weeks after they had migrated upstream to spawn--the average elapsed time from migration to recovery of the jaw tags was 21 days in 1965 and 26 days in 1966.

The cause of natural mortality in these spawners was not investigated. Many appeared to be in poor condition and several had been invaded by Saprolegnia. It is possible that some predation on cutthroat spawners occurred and that the carcasses were eaten or carried away. The only probable predators in the area were great blue herons which were occasionally observed. No evidence of the presence of mink or otter in the creek was ever noted. It is felt that fishing mortality was probably greater than the tag returns indicated, and that some of the spawners that could not be accounted for were probably caught by anglers.

The 1966 post-spawning mortality estimate of 53.5 percent is considered maximal since it was based on actual counts. Any cutthroat spawners that were missed during electro-fishing or that were in the portion of the creek that was not electro-fished would reduce this estimate. The 1965 post-spawning mortality estimate of 45.6 percent is only as reliable as the assumption that it was based on. Factors influencing mortality appeared to be about the same in both 1965 and 1966, and as the two estimates agree reasonably well, it is felt that the 1965 estimate may be reliable.

Although it is felt that fishing accounted for much of the post-spawning mortality observed during this study, it is interesting to note that the total mortality of post-spawning Snake River cutthroat was comparable to that of

Yellowstone cutthroat in Arnica Creek where fishing was not allowed. Ball and Cope (1961) reported mortalities of cutthroat spawners in this creek ranging from 35.3 to 50.3 percent in different years. It may be that such mortalities are to be expected in spawning cutthroat trout, and that fishing mortality merely replaced some of the natural mortality in Bar BC Spring Creek.

Consecutive Spawning by Cutthroat Trout

Twenty-two cutthroat trout or 19.0 percent of the 1966 Bar BC Spring Creek spawning run had been previously tagged. Twenty-one of these had been tagged as mature spawners in 1965 at the Bar BC Spring Creek fish trap. This indicated that 9.4 percent of the total 1965 cutthroat spawning run spawned again in 1966, and that 17.2 percent of the estimated number of surviving spawners that migrated out of the creek returned the following year. Ten of these repeat spawners were females, eleven were males.

This percentage of repeat spawning is higher than that reported in some cutthroat studies. Calhoun (1944) stated that 3.1 percent of the 1940 and 7.9 percent of the 1941 cutthroat spawning runs in Blue Lake, California represented repeat spawners. Ball and Cope (1961) reported that an average of 1.22 percent of the Yellowstone Lake spawning runs was composed of fish that had spawned before. They further indicated that alternate spawners returned in a greater percentage than did consecutive spawners. Snyder and Tanner (1960), however, estimated that 16 percent of the total 1958 cutthroat spawning run in one Trapper's Lake tributary spawned again in 1959.

In the 1965 Blue Crane Creek spawning run, six cutthroat trout were recaptured that had been previously tagged as mature spawners. One had been tagged in 1963 and five had been tagged in 1964--all at the Blue Crane Creek fish traps. In one instance, a male cutthroat is known to have spawned at least three times in four years. This particular trout was one of 26 cutthroat spawners that were tagged on June 15, 1962, during electro-fishing work in Bar BC Spring Creek. It was recaptured as a spawner on May 29, 1963, by electro-fishing in the same creek. On May 28, 1965, this same trout was captured in the Bar BC Spring Creek fish trap while migrating to spawn.

Homing Behavior of Cutthroat Trout

Other studies have reporting homing behavior in cutthroat trout. In 1955, Ball reported that none of 644 fin-clipped cutthroat trout fingerlings released in tributaries to Yellowstone Lake were recaptured in other streams than where they were released. After release, these trout migrated into Yellowstone Lake and then returned to the streams two or three years later to spawn. Between 1949 and 1953, 18,836 cutthroat spawners were tagged in five Yellowstone Lake tributary streams. Cope (1957b) indicated that only 3.2 percent of these tagged trout that were recaptured as repeat spawners were taken in streams other than where they were tagged.

Homing behavior information collected during this study is somewhat inconclusive. Of a total of 3,475 cutthroat that were fin-clipped at the Blue Crane Creek fish trap, 141 or 4 percent were recaptured at the same trap. All but one of these trout were immature when recaptured. Six immature cutthroat tagged in 1963 and 1964 at the Blue Crane Creek trap were recaptured in the same trap as spawners in 1965. Of a total of 2,000 hatchery cutthroat that were fin-clipped and planted in Bar BC Spring Creek in 1964, two were captured at the Bar BC Spring Creek trap in the 1966 spawning run. As previously mentioned, 21 cutthroat spawners tagged in 1965 at the Bar BC Spring Creek trap were recaptured in the same trap as spawners in 1966.

Three instances of straying were observed during this study. An immature cutthroat trout that was tagged at the Blue Crane Creek trap on March 16, 1963, was trapped as a spawner on July 5, 1965, in Bar BC Spring Creek. Another cutthroat that was trapped as a spawner in Bar BC Spring Creek had been fin-clipped at Blue Crane Creek. A third cutthroat tagged in the Snake River on April 6, 1965, was captured in Fish Creek as a spawner June 2, 1965, and was recaptured

in the 1966 Bar BC Spring Creek spawning run on June 19.

Population Estimates

Fish Creek

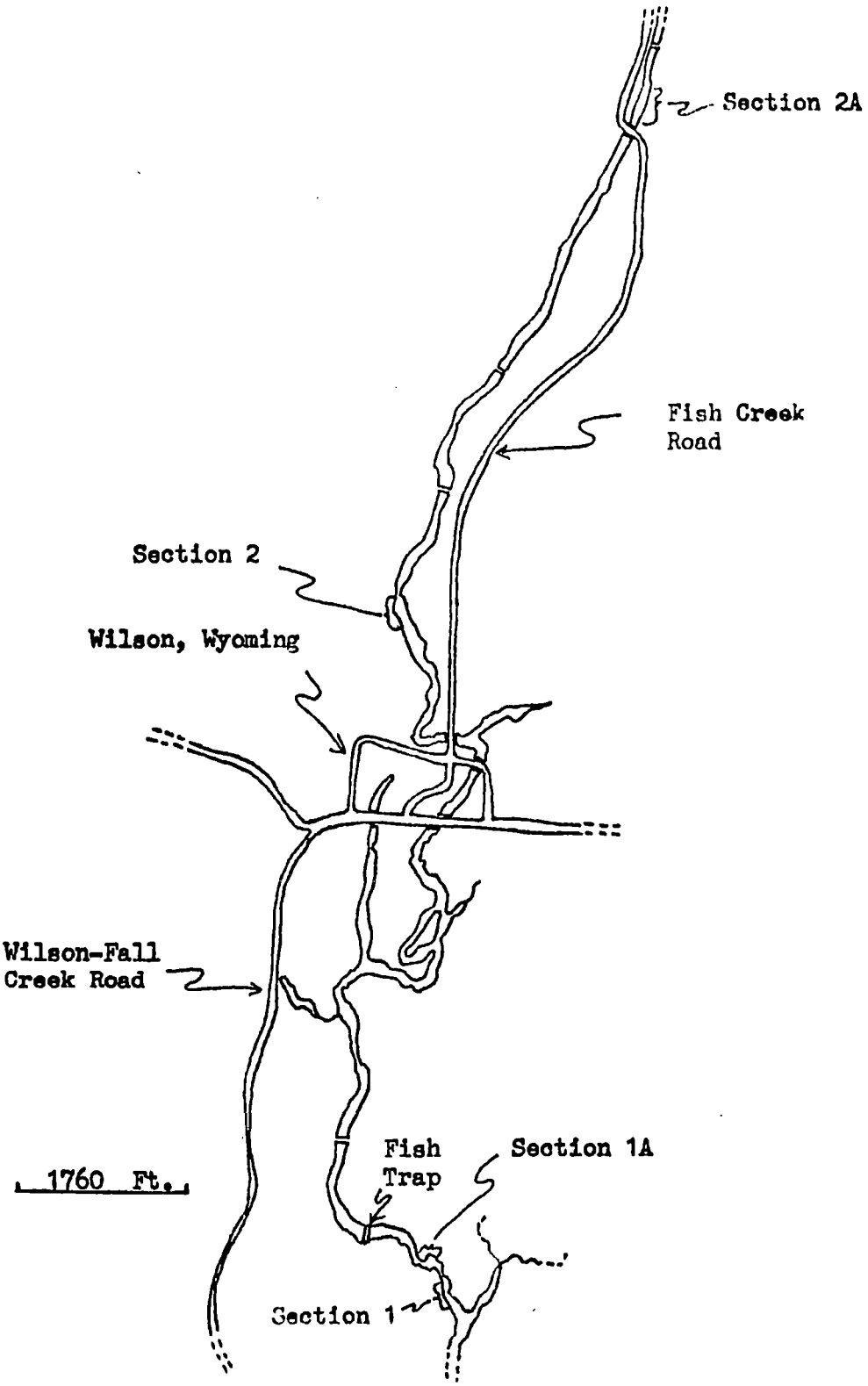
Electro-fishing estimates of the fish population in sections of Fish Creek were made in 1964, 1965, and 1966. Tables 7, 8 and 9 show the number of fish capatured in these operations and also show the calculated population for each stream section. Because of the small number of stream sections that were shocked and the large size of the stream, no attempt was made to expand these calculated estimates into an estimate of the total fish population.

Two stream sections were shocked in 1964 and 1965 and one stream section was shocked in 1966. The location of the downstream section was changed in 1965 after it was discovered that a number of small fish had escaped from the live cars during the second electro-fishing run in section 1. This new section (1A in Figure 20) was also shocked in 1966. A new upstream study section (2A) was shocked in 1965. It was felt that this section was more typical of the creek than was section 2 which was shocked in 1964. Because of the relatively poor catch of young-of-the-year cutthroat trout in these upstream study areas, no electro-fishing was done in this area in 1966.

The habitat in stream sections 1 and 1A were quite similar and it is felt that the data for the years 1964, 1965, and 1966 are comparable. Both sections contained nearly equal areas of cover and slow water. Sections 2 and 2A consisted of deep holes and shallow riffles and were considered to be comparable. Tables 10 and 11 give the number and composition of cutthroat trout populations in both the upstream and downstream study areas.

Only three young-of-the-year cutthroat were captured in the upstream study sections. It is likely that if more sections had been shocked in this area, more young cutthroat would have been captured since they were

Fig. 20. Fish Creek Electrofishing Sections



commonly observed in small side channels or under stream banks. Although young-of-the-year cutthroat comprised 25 percent of all the cutthroat captured in section 2A in 1965, the total sample of cutthroat was so small (12) that this figure has little value.

TABLE 7

Fish Captured During 1964 Electro-fishing Operation in Fish Creek

SECTION 1: Total length - 300 feet: Electro-fished 11-17-64

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	23	7	2	0	31
Second Run	19	1	0	0	7
Third Run	15	0	0	0	4
Total	57	8	2	0	42
Calculated Population for Section	121.6	8.1	(2)	(0)	42.2

SECTION 2: Total length - 300 feet: Electro-fished 11-17-64

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	0	29	20	12	59
Second Run	0	5	3	4	0
Third Run	0	0	0	0	7
Total	0	34	23	16	66
Calculated Population for Section	(0)	34.5	23.5	16.6	62.8

TABLE 8

Fish Captured During 1965 Electro-fishing Operation in Fish Creek

SECTION 1A: Total length - 318 feet: Electro-fished 10-20-65

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	85	6	0	8	0
Second Run	22	0	0	2	1
Third Run	8	2	0	1	1
Total	115	8	0	11	2
Calculated Population for Section	116.8	7.2	(0)	11.1	(2)

SECTION 2A: Total length - 335 feet: Electro-fished 10-20-65

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	2	5	0	20	-*
Second Run	1	4	0	7	-
Third Run	0	0	0	0	-
Total	3	9	0	27	-
Calculated Population for Section	3.2	10.2	(0)	28.1	-

* No Record

TABLE 9

Fish Captured During 1966 Electro-fishing Operation in Fish Creek

SECTION 1A: Total length - 318 feet: Electro-fished 10-19-66

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	64	3	13	3	13
Second Run	17	1	1	3	1
Third Run	9	0	1	0	1
Total	90	4	15	6	15
Calculated Population for Section	91.5	5.1	14.7	7.0	14.7

UPSTREAM SECTION NOT ELECTRO-FISHED

TABLE 10

Number and Composition of the Calculated Cutthroat Trout Population in the Upstream Study Sections of Fish Creek

	1964	1965
Total Calculated Number of Cutthroat Trout	57.7	13.4
Calculated Number of Young-of-the-Year Cutthroat Trout	0	3.2
Calculated Number of Older Cutthroat Trout	34.5	10.2
Calculated Number of Hatchery Cutthroat Trout	23.2	0
Percent Young-of-the-Year Cutthroat of Calculated Total	0.0%	25.0%
Percent Older Cutthoat of Calculated Total	59.8%	75.0%
Percent Hatchery Cutthroat of Calculated Total	40.2%	0.0%
Total Calculated Number of Cutthroat per 100 feet of Creek	19.2	4.0
Calculated Number of Young-of-the Year Cutthroat per 100 feet	0	1.0

TABLE 11

Number and Composition of the Calculated Cutthroat Trout Population in the Downstream Study Sections of Fish Creek

	1964	1965	1966
Total Calculated Number of Cutthroat Trout	131.7	124.0	111.3
Calculated Number of Young-of-the Year Cutthroat Trout	121.6	116.8	91.5
Calculated Number of Older Cutthroat Trout	8.1	7.2	5.1
Calculated Number of Hatchery Cutthroat Trout	2	0	14.7
Percent Young-of-the-Year Cutthroat of Calculated Total	92.3%	94.2%	82.2%
Percent Older Cutthroat of Calculated Total	6.2%	5.8%	4.6%
Percent Hatchery Cutthroat of Calculated Total	1.5%	0.0%	13.2%
Total Calculated Number of Cutthroat per 100 feet of Creek	43.9	39.0	35.0
Calculated Number of Young-of-the-Year Cutthroat per 100 feet	40.5	36.7	28.8

As previously mentioned, both upstream study sections had similar habitat. The upstream end of section 2 terminated at a log dam. A deep hole downstream from this dam provided good habitat for larger trout and whitefish. Section 2A consisted of a deep hole between two riffles and also provided good habitat for large fish. It is felt that the major reason for the smaller trout population in section 2A was the presence of a large whitefish population. Records were not kept of the number of whitefish removed from this area in 1965, but 364 large (12 to 16 inches total length) whitefish were shocked from this area in 1966. It was observed during this study that few trout were to be found with large schools of whitefish. This observation has also been made in other streams by area fisheries management personnel. The reason for this is not known, but it is suggested that competition for space might be partially responsible.

Brook trout were more abundant at stations 2 and 2A. No definite reasons for this were established, but spawning areas may be more suitable and competition less upstream. Whitefish were less abundant at station 2, and were usually observed to be concentrated in deep holes. This species seems to prefer slow-moving water that is at least three feet deep, and this type of habitat was more common in the downstream sections of Fish Creek.

Young-of-the-year trout comprised 89.6 percent of the total calculated cutthroat trout population in the downstream study sections for all three years. This high percentage indicates that the habitats in these specific sections were suitable for small trout. Both section 1 and 1A contained considerable areas of slow water, aquatic vegetation, and overhanging stream banks. Such areas were less extensive in sections 2 and 2A.

Table 11 indicates a decline in the cutthroat trout population in the downstream study sections. The fact that the 1966 cutthroat spawning run was smaller than the 1965 spawning run may actually have caused a reduction in the total number of 1966 young-of-the-year cutthroat in this part of Fish Creek. Because only one study section each year was shocked in the downstream portion of the creek, it cannot be assumed that the cutthroat population declined throughout the whole area.

In August 1966, nearly 40,000 young-of-the-year hatchery cutthroat were released in Fish Creek. These fish comprised 13.2 percent of the 1966 total calculated cutthroat population in study section 1A and 13.6 percent of the 1966 catch of cutthroat fingerlings in the fish trap. They were released some distance upstream and drifted into the area. Older fin-clipped hatchery cutthroat comprised 40.2 percent of the total population in study section 2 in 1964. These fish were planted a short distance upstream from this section and apparently concentrated in the deep hole below the log dam.

The following releases of hatchery cutthroat were made in Fish Creek during this study:

DATE	NUMBER	SIZE	MARK
7-13-64	6,009	5-8"	100% Right and Left Pelvic
8-11-65	1,001	7-8"	100% Right Pelvic and Adipose
8-1-66	39,722	2"	10% Adipose
8-18-66	999	8"	None

Hatchery cutthroat could be recognized by clipped fins, eroded fins. or size. Most young-of-the-year wild cutthroat that were captured by electro-fishing or in the fish trap were 1.5 to 2.4 inches long. Observations in both 1965 and 1966 indicated that wild cutthroat spawned during the year were seldom over three inches long in November. For this reason,

all young-of-the-year cutthroat captured by electro-fishing or trapped in the overpour trap that were 3.0 to 4.5 inches long were considered to be hatchery fish.

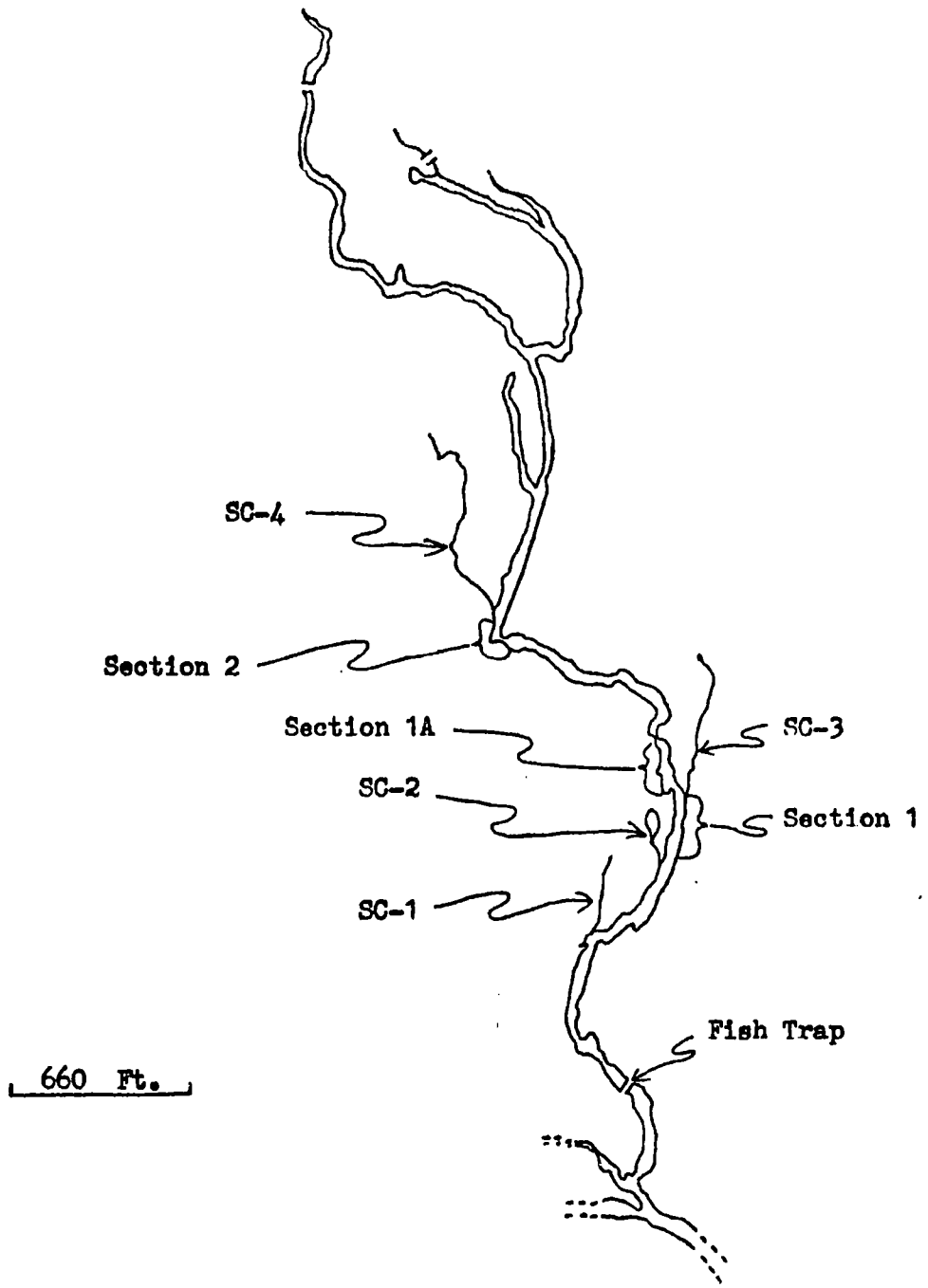
Bar BC Spring Creek

Estimates were made of cutthroat trout and whitefish populations in the lower 3,100 feet of Bar BC Spring Creek. During this study, no cutthroat or whitefish were captured by electro-fishing or observed to inhabit the creek above electro-fishing section 2. Brook trout were observed throughout the creek and estimates of their numbers were made for the entire stream.

Tables 12, 13 and 14 indicate the number of cutthroat trout, brook trout and whitefish captured each year in the two electro-fishing sections. The location of section 1 was moved upstream about 200 feet in 1965 after a number of fish escaped from the live car during the second electro-fishing run. This new electro-fishing section was designated 1A (see Figure 21). Table 15 indicates the estimated total population of cutthroat trout, brook trout, and whitefish in Bar BC Spring Creek for 1964, 1965 and 1966.

Estimates of the total population of older cutthroat trout and all whitefish were made by dividing the sum of the calculated populations obtained from the electro-fishing sections each year by the total length of the two sections. This number was multiplied by 3,108--the total length of the creek where these species were observed. To obtain estimates of the total brook trout population, a similar calculation was used. The sum of the two calculated stream section populations for each year was divided by the total length of the sections. This number was multiplied by 4,194, the total length of the creek below where it branches. The same number was then multiplied by the total length of the two tributaries (3,276 feet) and

Fig. 21. Bar BC Spring Creek Electrofishing Sections



divided by two. Since water flows in each tributary were about one-half that of the main stream, it was assumed that the average brook trout population was also one-half. The two products were summed for an estimate of the brook trout population in the entire creek.

Each year, considerable differences were observed in the number of young-of-the-year cutthroat trout captured in the two electro-fishing sections. It is felt that these differences were mostly due to differences in habitat and the location of cutthroat spawning areas. During the electro-fishing operations it was observed that most fingerling cutthroat inhabited slow-water areas where cover was abundant, and considerable effort was made to thoroughly shock these areas. All fingerling cutthroat captured in riffle areas were taken near the stream bank. The middle three-fourths of section 1A and the upstream one-third of section 2 were pool areas containing extensive beds of aquatic vegetation. All of section 1 and the lower two-thirds of section 2 consisted of riffle areas.

A general correlation between the number and location of cutthroat redds and the number of cutthroat fingerlings in section 2 indicated that most young cutthroat moved downstream after emerging from the gravel. No fingerling cutthroat were observed in the creek above the uppermost cutthroat redds. In 1964, four cutthroat redds were observed in section 2 and three redds were observed directly upstream. No cutthroat redds were observed in section 2 either in 1965 or 1966, but 1 and 4 redds respectively, were observed directly upstream. The calculated number of fingerling cutthroat in section 2 was 164.3, 25.5, and 61.5 for these three years.

Estimates of the total population of young-of-the-year cutthoat trout in Bar BC Spring Creek were adjusted somewhat arbitrarily on the basis of observed habitat preference and location of spawning areas. It was assumed

TABLE 12

Fish Captured During 1964 Electro-fishing
Operation in Bar BC Spring Creek

SECTION 1: Total length - 300 feet: Electro-fished 10-21-64

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	16	5	6	48	10
Second Run	16	3	9	21	4
Third Run	6	2	0	13	1
Total	38	10	15	82	15
Calculated Population for Section	61.9	12.5	18.2	91.9	15.9

SECTION 2: Total length - 300 feet: Electro-fished 10-22-64

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	63	1	9	59	9
Second Run	47	0	1	19	0
Third Run	18	0	1	9	1
Total	128	1	11	87	10
Calculated Population for Section	164.3	1.0	10.7	90.3	9.0

TABLE 13

Fish Captured During 1965 Electro-fishing Operation in Bar BC Spring Creek

SECTION 1A: Total length - 171 feet: Electro-fished 10-21-65

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	183	8	0	21	2
Second Run	116	3	0	9	3
Third Run	70	1	0	5	0
Total	369	12	0	35	5
Calculated Population for Section	486.9	12.6	(0)	38.5	6.0

SECTION 2: Total length - 300 feet: Electro-fished 10-19-65

	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	14	10	0	35	8
Second Run	3	1	0	18	1
Third Run	7	0	0	1	2
Total	24	11	0	54	11
Calculated Population for Section	25.5	11.0	(0)	58.4	10.6

TABLE 14

Fish Captured During 1966 Electro-fishing Operation in Bar BC Spring Creek

SECTION 1A: Total Length - 171 feet: Electro-fished 10-17-66					
	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	143	4	0	23	1
Second Run	64	0	0	4	0
Third Run	30	0	0	4	0
Total	237	4	0	31	1
Calculated Population for Section	261.1	(4)	(0)	30.5	(1)

SECTION 2: Total Length - 300 feet: Electro-fished 10-18-66					
	Fingerling Cutthroat	Older Cutthroat	Hatchery Cutthroat	Brook Trout	White-fish
First Run	37	0	0	37	2
Second Run	13	0	0	23	4
Third Run	8	2	0	11	0
Total	58	2	0	71	6
Calculated Population for Section	61.5	(2)	(0)	87.6	7.2

TABLE 15

Estimate of Total Fish Population in Bar BC Spring Creek in 1964, 1965, and 1966

	1964	1965	1966
Fingerling Cutthroat	1,319	5,164	3,041
Older Cutthroat	70	156	39
Hatchery Cutthroat	150	0	0
Brook Trout (1)	1,771	1,211	1,420
Whitefish (2)	129	109	54
TOTAL	3,439	6,640	4,554

(1) Estimate for the total length of the creek

(2) All whitefish were in age class 0+

that no cutthroat fingerlings inhabited the creek above the uppermost cutthroat spawning redds. In 1965, two major spring channels (SC-1 and SC-3 in Figure 21) were electro-fished and a total of 557 fingerling cutthroat were captured. This number was 12.1 percent of the 1965 calculated population of young cutthroat in the main portion of the creek and was added to this number. It was assumed that 12 percent of the calculated population of fingerling cutthroat in the main portion of the creek also inhabited these two channels in 1964 and 1966.

Of the 3,108 feet between the mouth of the creek and the upper end of electro-fishing section 2, 1,572 feet consisted of pools and 1,536 feet consisted of riffles. Calculated population estimates obtained in section 2 in 1964 and in section 1A in 1965 and 1966 were multiplied by the total length of pool habitat. The estimates obtained in section 1 in 1964 and in section 2 in 1965 and 1966 were multiplied by the total length of the riffle habitat. These two products were summed to estimate the population in the main portion of the creek. This number plus 12 percent gave an estimate of the total young-of-the-year cutthroat trout population in the Bar BC Spring Creek.

On September 1, 1964, before any population estimates were made, the lower 2,500 feet of Bar BC Spring Creek was electro-fished once to obtain some idea of the nature of the fish population. Because of the distance to be covered, no attempt was made to electro-fish all areas of vegetation and only those fish that were readily shocked were captured. It was recognized during this operation that a large number of the smaller fish were missed by both the shocker and the dip nets. One-hundred and thirty-three cutthoat trout, 189 brook trout, 3 rainbow cutthroat hybrids, and 2 whitefish were captured. A single rainbow trout spawner and one Pantosteus sucker captured

in the fish trap were the only other species observed in Bar BC Spring Creek during this study.

Of the 133 cutthroat trout, 36 (27.1 percent) were hatchery fish. These came from a plant of 2,000 fin-clipped cutthroat fingerlings made on July 20, 1964. No hatchery cutthroat were captured or observed to be in the creek in 1965 or 1966, and it is assumed that the survivors of this plant migrated out of the creek during the winter of 1964-1965. In 1966, two of these fin-clipped cutthroat migrated into the creek to spawn and were captured in the fish trap. Of the 97 wild cutthroat captured in September 1964, five were adults (over 12 inches long), 26 were judged to be yearlings or sub-adults (4.5 to 12.0 inches long), and the remainder were young-of-the-year trout. The population and trapping data obtained during this study indicated that Bar BC Spring Creek supported only a small resident population of cutthroat trout, but served as an important spawning and nursery stream for this species.

The cutthroat trout population in Bar BC Spring Creek consisted mostly of immature fish during the three years of this study. Young-of-the-year trout comprised 95.0, 97.1, and 98.7 percent of the total wild cutthroat trout population in 1964, 1965, and 1966. For these same years, adult cutthroat comprised 0.7, 0.3, and 0.3 percent, while yearling or sub-adult cutthroat comprised 4.3, 2.6, and 1.0 percent of the population. Eighty-five percent of the rainbow trout population of Trout Creek, Montana, was composed of young-of-the-year fish according to Holton (1953). He indicated that the paucity of older fish in this creek was due to a population turnover that exceeded the observed mortality, but was uncertain about the actual cause of such a turnover. The higher percentages of young-of-the-year cutthroat in Bar BC Spring Creek indicated an even higher rate of population turnover. In this case, it is felt that migration from the creek was the major factor in this lack of population stability.

No adult whitefish were observed to inhabit Bar BC Spring Creek. The few whitefish captured by electro-fishing were fingerlings and were presumed to be in age class 0+(i.e.young-of-the-previous year of a fall-spawning species). Several whitefish were captured in the fish trap while migrating into the creek, but were not released upstream. Whitefish apparently utilized this creek only for spawning purposes.

One rainbow trout and eight rainbow-cutthroat hybrids migrated into Bar BC Spring Creek in late April and early May of 1965. None were captured in 1966 although it is possible some may have migrated into the creek, spawned, and returned to the river before the trap was installed on May 26. These fish probably came from the Gros Ventre River where a small resident rainbow trout population maintains itself.

Brook trout inhabited Bar BC Spring Creek throughout the year and very few were captured in the fish trap while moving either into or out of the creek. Most of the brook trout captured by electro-fishing were 3.5 to 6.0 inches long and were judged to be in age class 0+. In 1964, 85.5 percent of the total number of brook trout captured were in this age class, while in 1965, they made up 82.0 percent of the total. These figures agree with those reported by Holton (1953), who indicated that 80 percent of the brook trout population in Trout Creek, Montana, were in age class 0. In 1966, there was a decline in the number of older brook trout. Of the total number of brook trout captured in October, 93.7 percent were young-of-the-previous year. It is unlikely that fishermen harvested enough brook trout from Bar BC Spring Creek to account for this decline, and the reason for it is not known.

In Bar BC Spring Creek,the calculated number of young-of-the-year cutthroat trout per mile of stream was 2,441 in 1964, 8.773 in 1965, and 5,166 in 1966. For the same years, the number of young-of-the-year brook trout was 1,520, 993, and 1,330 per stream mile. Holton (1953) calculated the number of young-of-the-year trout per mile in Trout Creek, Montana. His figures were 5,867 in 1950 and 5,468 in 1951; of which in 1950, 5,456 were rainbow and 352 were brook trout; and in 1951, 3,992 were rainbow and 1,312 were brook trout.

Because Trout Creek has a more variable temperature regimen and less than one-half the average volume of Bar BC Spring Creek, a good comparason cannot be made. It is felt however, that the total fish population of Bar BC Spring Creek was not large for a stream that appeared to be quite productive. Although no analysis was made of the food organisms,

it is felt that good would not be a limiting factor in this creek. Predation by larger fish is one possible explanation and underestimation of the fish population during this study is still another. It is also possible that the fact that this creek was inhabited almost exclusively by trout may have in some way limited the total number of fish.

Fecundity of Cutthroat Trout Spawners

In 1965, five cutthroat females taken in the Bar BC Spring Creek trap were sacrificed for their ovaries. The eggs were counted and it was determined that these females contained an average of 2,313 eggs. In 1966, eight females were similarly sacrificed and found to contain an average of 2,302 eggs. Three females sacrificed in 1965 from the Blue Crane Creek trap were found to contain an average of 2,309 eggs. The overall average for these three groups was 2,308 eggs per female.

The eggs were artificially spawned from eight cutthroat females at the Fish Creek trap in 1965, and from seven females at the Bar BC Spring Creek trap in 1966. These eggs were taken to establish a brood stock by Wyoming Game and Fish Department employees. A total of 35,093 eggs were stripped from these fish for an average of 2,340 eggs per female. Although this number agrees with that obtained by counts, these females were larger than average--2.12 pounds each as compared to the average of 1.79 pounds each. It seems likely that an undetermined number of eggs were left in these fish while all eggs were removed from those females that were sacrificed. Snyder and Tanner (1960) stated that an average of 350 eggs was found on dissection of eleven artificially spawned female cutthroat trout at Trapper's Lake, Colorado. They further cited an article by Hobbs, who indicated that an average of eight eggs or less than one percent was retained by trout after natural spawning. Smith

(1941) also stated that fewer than ten eggs were retained by natually spawned cutthroat trout. For the purpose of estimating the total egg production, it was assumed that each female cutthroat produced 2,308 eggs and retained 8 eggs after spawning.

Mortality of Cutthroat Trout Eggs

Five cutthroat trout redds were excavated in Bar BC Spring Creek after the 1965 spawning run. Fewer than ten eggs were recovered from three of these redds and it was apparent that the excavation technique and equipment used were not satisfactory. In 1966, fifteen redds were excavated in this creek with modified equipment. Table 16 indicates the number, development and mortality of 17 redd samples. The three redds excavated in 1965 that yielded fewer than ten eggs were not tabulated.

The average mortality for all redd samples was 11.5 percent and the average number of eggs per redd was 282. Few eggs were recovered from several redds that were excavated in deep water (more than 12 inches). The egg net appeared to create turbulence and an undetermined number of eggs were observed to flow around it. In several other redds, very few eggs were observed at all--either they were lost in the current or the egg pockets in the redd were not uncovered. Mills (personal communication, 1965) stated that he recovered an average of 300 to 400 eggs per sampled redd. For these reasons, only those samples containing at least 100 eggs were used to calculate egg mortalities. Sample number 66-9 obviously consisted of several redds created by different trout, and therefore was not used in the calculation of mortalities.

The average mortality for ten samples containing over 100 eggs was

TABLE 16

Mortality of Cutthroat Trout Eggs from Natural Redds
in Bar BC Spring Creek

SAMPLE #	TOTAL # EGGS	# ALIVE	% MORTALITY	DEVELOPMENT
65-2	139	130	6.5	Pre-eyed
65-4	173	161	6.9	Pre-eyed
66-1	124	120	3.2	Pre-eyed
66-2	595	579	2.7	Pre-eyed
66-3	970	953	1.8	Pre-eyed
66-4	37	33	10.8	Pre-eyed
66-5	38	32	15.8	Pre-eyed
66-6	381	356	6.6	Pre-eyed
66-7	361	348	3.6	Pre-eyed
66-8	363	355	2.2	Pre-eyed
66-9	273	241	11.7	Pre-eyed, Eyed, Alevin
66-10	300	289	3.7	Eyed
66-11	70	18	74.3	Pre-eyed
66-12	38	34	10.5	Eyed
66-13	858	798	7.0	Eyed
66-14	89	78	12.4	Pre-eyed
66-15	12	10	16.7	Eyed

4.4 percent and the average number of eggs per sample was 426. This mortality is lower than that reported in other cutthroat trout studies. Ball and Cope (1961) reported 60 to 75 percent cutthroat egg mortality in Yellowstone Lake tributaries while Snyder and Tanner (1960) reported 45 percent mortality in a hatchery box experiment in three tributaries to Trapper's Lake, Colorado. In a more thorough study of cutthroat trout egg mortality, Mills (1966) reported average mortalities of 12.1 to 41.8 percent in naturally spawned cutthroat redds in three Yellowstone Lake tributaries.

Mills (1966) believed that the presence of silt was the one variable most highly correlated with egg mortality. He also stated that silt, gravel size, and minimum oxygen are inter-related and probably accounted for much of the mortality he observed. Warner (1963) reported an average mortality of 6.8 percent for natually spawned landlocked salmon (Salmo salar) eggs with stable water and temperature conditions and no siltation. As previously indicated, most cutthroat redds in Bar BC Spring Creek were found in areas of clean rounded gravel. Little siltation of the redds was observed and the high survival of cutthroat trout eggs in this creek may be due to this fact. Sample number 66-11 was taken from a redd located at an old beaver dam. This redd was covered with silt and other organic debris and the eggs suffered the highest mortality observed in the study (74.3%).

Coble (1960) indicated a positive correlation between the apparent velocity of the ground water, the dissolved oxygen concentration of the ground water, and embryonic survival of steelhead trout. The apparent velocity of the ground water and the dissolved oxygen concentrations were

closely related and the effects of these factors could not be separated. Two determinations of the dissolved oxygen concentration in the intra-gravel water were made in Bar BC Spring Creek. In one area, the dissolved oxygen concentration in the creek was 9.0 and in the intra-gravel water was 6.2, while in another area, the values were 8.2 and 6.0 respectively. According to Coble (1960), these concentrations are favorable for the development of trout eggs.

Because of the small number of samples obtained, no attempt was made to determine at what stage of development most of the mortality occurred. Mills (1966) stated that pre-eyed mortality accounted for an average of 92.7 percent of the total egg mortality, while Warner (1963) reported that over 60 percent of the total mortality occurred in the pre-eyed stage.

Mortality of Cutthroat Trout Fry

Estimates of cutthroat trout fry mortality in Bar BC Spring Creek were calculated for 1965 and 1966. These estimates were based on calculated young-of-the-year cutthroat populations and known number of female spawners. For the purposes of these calculations, it was assumed that each female cutthroat deposited 2,300 eggs and that five percent of these eggs did not hatch.

In 1965, 105 female cutthroat spawned upstream and seven spawned downstream from the fish trap. A total of 257,600 eggs were deposited less five percent to yield a total of 244,720 cutthroat fry hatched. The calculated young-of-the-year cutthroat population in late October was 5,164. This number divided by the total number hatched gave an estimate of 2.11 percent survival or a total mortality of 97.89 percent. For 1966, the figures were sixty female cutthroat, 131,100 cutthroat fry hatched, 3,041 young-of-the-year cutthroat in October, and survival of 2.32 percent or 97.68 percent mortality.

Smith (1947) reported 0.04 to 5.98 percent survival of cutthroat trout fry over a similar period. In his experiment, cutthroat trout were induced to spawn in screened-off sections of Convict Creek, California. These sections were drained in late October and all young-of-the-year cutthroat were counted. Shetter (1961) reported brook trout fry survival of 4.5 to 31.7 percent by this method, and of 2.7 to 6.7 percent by a method similar to the one used in the present study. Survival of cutthroat fry from hatching to September in Arnica Creek varied from less than one percent to 4.3 percent according to Ball and Cope (1961).

The peak for emergence of cutthroat trout fry in Bar BC Spring Creek occurred about fifty days after the peak of the spawning run. The median time of emergence was August 12, and the electro-fishing estimates were made about seventy days later. The daily instantaneous mortality rate for the cutthroat fry was calculated as follows for 1965:

$$i = \frac{\log_e N_t/N_o}{t} = -\frac{\log_e 0.0211}{70} = 0.055$$

and for 1966, the daily instantaneous mortality rate was 0.054.

Obviously, such a high mortality rate could not continue for long or not a single fish would remain at the end of the first year. Both Smith (1947) and Shetter (1961) indicated that the highest mortality occurred shortly after the fry emerge from the gravel. Allen (1951) also reported that the mortality rate is much greater during the first three months after hatching than it is in the following year.

Mason and Chapman (1965) reported that coho salmon fry exhibited aggressive behavior one week after they emerged from the gravel. They further indicated that the first fry to emerge had an ecological advantage and were larger and more abundant in terminal populations. A large variation in the size of the cutthroat trout fry (1.2 to 3.9 inches) was observed during the electro-fishing work in Bar BC Spring Creek. The early-emerging cutthroat fry in this creek may occupy the most favorable habitat and thus force the late-emerging and smaller fry into less favorable situations where they would be more susceptible to predation or be forced to migrate downstream.

Smith (1947) reported that a large downstream migration of cutthroat fry occurred just after emergence from the gravel in 1940. Benson (1960) and Snyder and Tanner (1960) also indicated that cutthroat fry migrate

downstream soon after they emerge. Because of the design of the fish trap and large amounts of floating vegetation, downstream-migrating cutthroat fry could not be captured in the Bar BC Spring Creek trap. To determine whether cutthroat fry migrated downstream prior to the electro-fishing work in 1965, a fry trap was installed a short distance downstream from the fish trap. The data obtained from this fry trap indicated that young-of-the-year cutthroat migrated downstream in some numbers during September.

It seems likely that the estimates of fry mortality in Bar BC Spring Creek are higher than the actual mortality because of early downstream migration. No information on the number of cutthroat fry migrating out of the creek in September was obtained, but very few moved downstream during October, November, and December of 1965.

Downstream Migration of Cutthroat Trout Fingerlings

Information was obtained on the downstream migration of young-of-the-year cutthroat trout in all the study tributaries. Data on the total number of downstream-migrating cutthroat were obtained in 1963 and 1964 in Blue Crane Creek where the overpour trap was very effective in capturing small fish. After modification of the Fish Creek trap (Appendix 1, Fish Division Administrative Report No. 0164-17-6701), fair information on downstream migration was obtained in this creek. Downstream trapping in Bar BC Spring Creek was not successful because of the large amount of floating vegetation, and only trend data were obtained from fry traps.

As indicated by Figures 22 and 23, the peak of downstream migration occurred during January and February in Blue Crane Creek. Cutthroat that had spent at least one year in the creek before migrating downstream through the fish trap comprised 38.1 percent of the total in the winter of 1962-1963, 44.5 percent in 1963-1964, and 61.0 percent in 1964-1965. Benson (1960)

Fig. 22. Number of Fingerling Cutthroat Migrating Downstream Through the Blue Crane Creek Overpour Trap

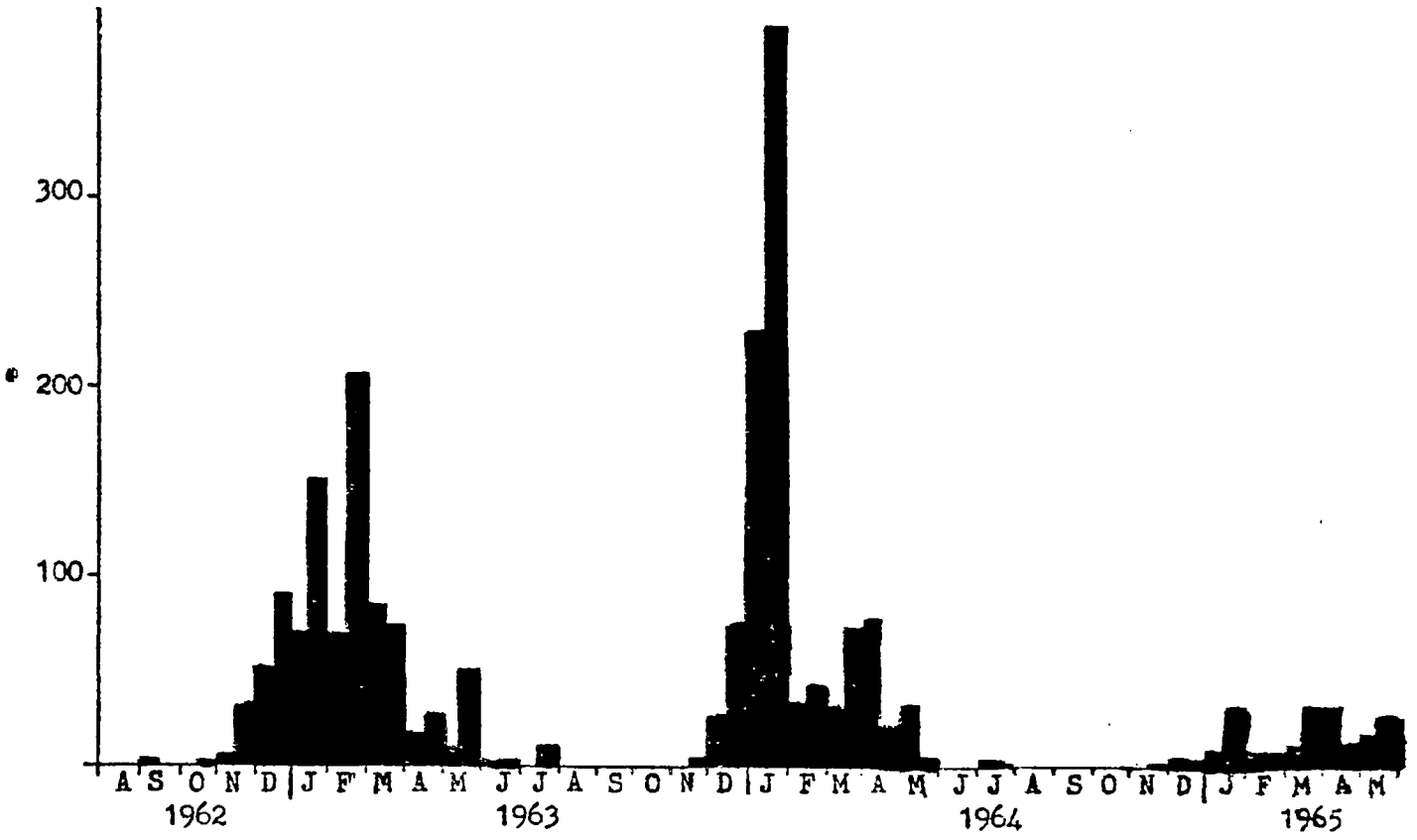
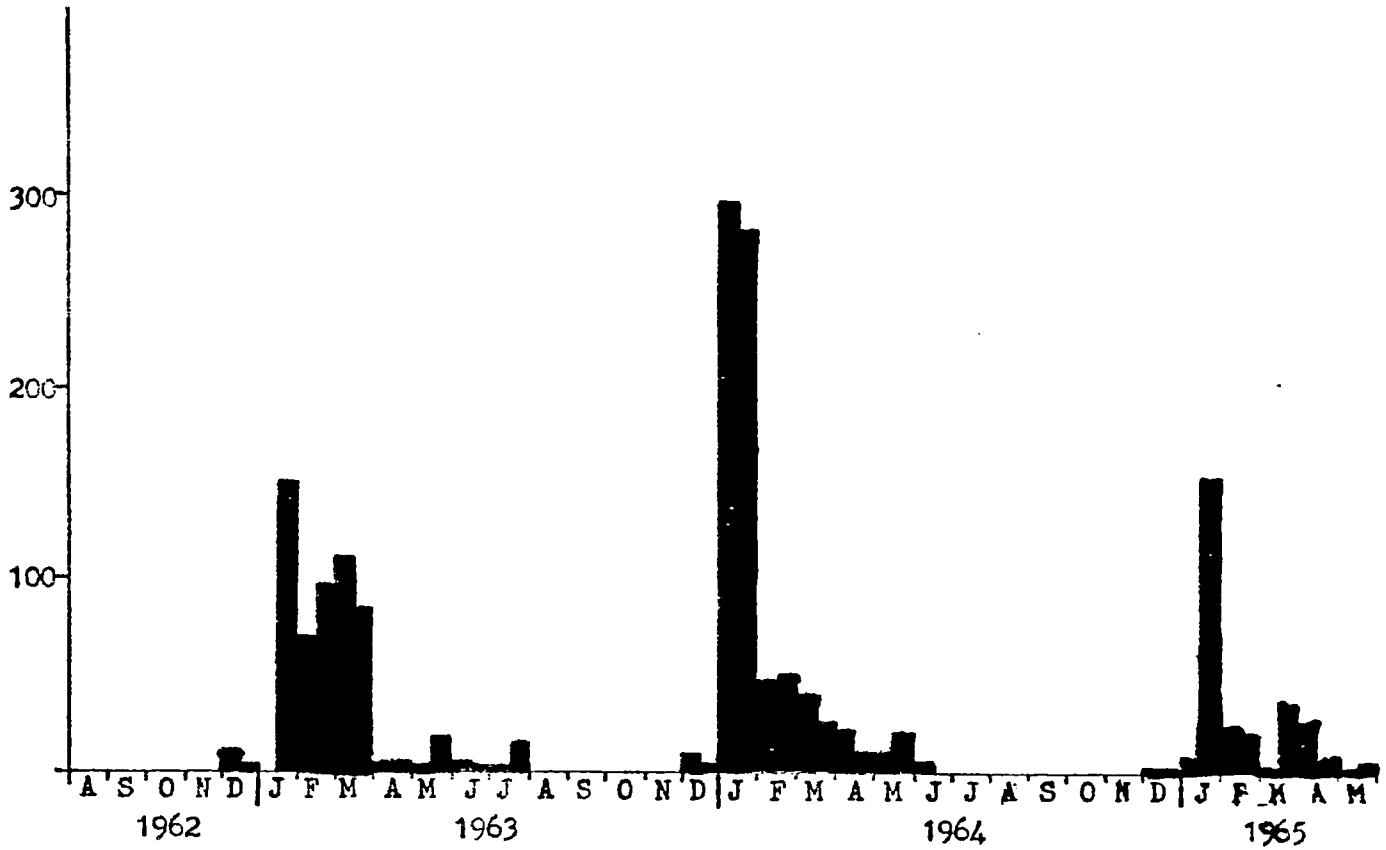


Fig. 23. Number of Age I & II Cutthroat Migrating Downstream Through the Blue Crane Creek Overpour Trap



reported that age I and II cutthroat comprised an average of 12.7 percent of the total number trapped in Arnica Creek between 1950 and 1958. The extremes ranged from 3.9 to 67.3 percent. Bjornn (1961) stated that most cutthroat spent two or three years in tributary streams before entering Priest and Upper Priest Lakes in Idaho.

Benson (1960) and Snyder and Tanner (1960) reported that cutthroat fry usually migrate downstream shortly after they emerge from the gravel. It was initially thought that such late migration in Blue Crane Creek might be an anomaly due to stream morphometry. The dam across the mouth of Blue Crane Creek created a pond habitat from the fish trap upstream for about 800 feet. It was thought that cutthroat fry migrating downstream in the summer and early fall might remain in this area until winter when reduction of cover and food would cause them to again move downstream and through the fish trap.

No evidence of early downstream migration of cutthroat fry was obtained in either Blue Crane Creek or Spring Creek. In July 1964, a fry trap was set in several locations upstream from the fish trap, and in 1965, another fry trap was set in Spring Creek during July and August. No young-of-the-year cutthroat were trapped in the first trap and only one was taken in the second trap. Two cutthroat fingerlings were captured in the Blue Crane Creek overpour trap in July 1964, but none were trapped at this time in any other year. Other than the fry trap information obtained in 1965, nothing was known of downstream migration in Spring Creek.

It is believed that the small number of cutthroat checked down through the Blue Crane Creek trap in 1965 was mostly due to the flood on December 23, 1964, which demolished the overpour trap. Many fingerlings probably passed downstream during the flood or in the nine days that the fish trap was not operating--December 23 to 31, 1964. The total number of spawners

observed in 1965 was similar to that in previous years, and there was no evidence of poor survival of cutthroat fry in 1965.

No young-of-the-year cutthroat trout were captured in Fish Creek until the overpour traps were installed in September 1965. Downstream trapping in Fish Creek was not possible until the water flow had fallen below about 200 cfs. Nothing is known of the number of cutthroat fry that may have migrated downstream during July, August and September. Although no such early migration was detected in Blue Crane Creek during the present study, there is evidence that fry migrated downstream in Bar BC Spring Creek in September 1965. Benson (1960) stated that 77.5 percent of all ago 0 cutthroat trapped in Arnica Creek moved downstream in July and August.

Neave (1955) reported that downstream migrating salmon fry tended to move at night and near the banks of the stream. For this reason, the two overpour traps in Fish Creek were located close to the stream banks. The center section of the trap was not screened in order to pass a large volume of water and to trap larger fish (Appendix 1, Fish Division Administrative Report No. 0164-17-6701) and it is certain that some escapement of cutthroat fry occurred through this section. For this reason, the data obtained in Fish Creek were not quantitative.

Figure 24 shows the number of wild young-of-the-year cutthroat trout captured in the Fish Creek overpour traps in 1965 and 1966. In both 1966 and 1967, the number of fingerlings migrating downstream increased during the first week of January and it is probable that the migration continued for some time into the winter. Not indicated in the figure is the number of hatchery cutthroat captured in the overpour traps. Four catchable hatchery cutthtroat were trapped in 1965 while 79 hatchery fingerling cutthroat were captured in 1966. This was 13.6 percent of the total number of age 0 cutthroat captured in that year.

Fig. 24. Number of Fingerling Cutthroat Trapped per Week in the Fish Creek Overpour Traps

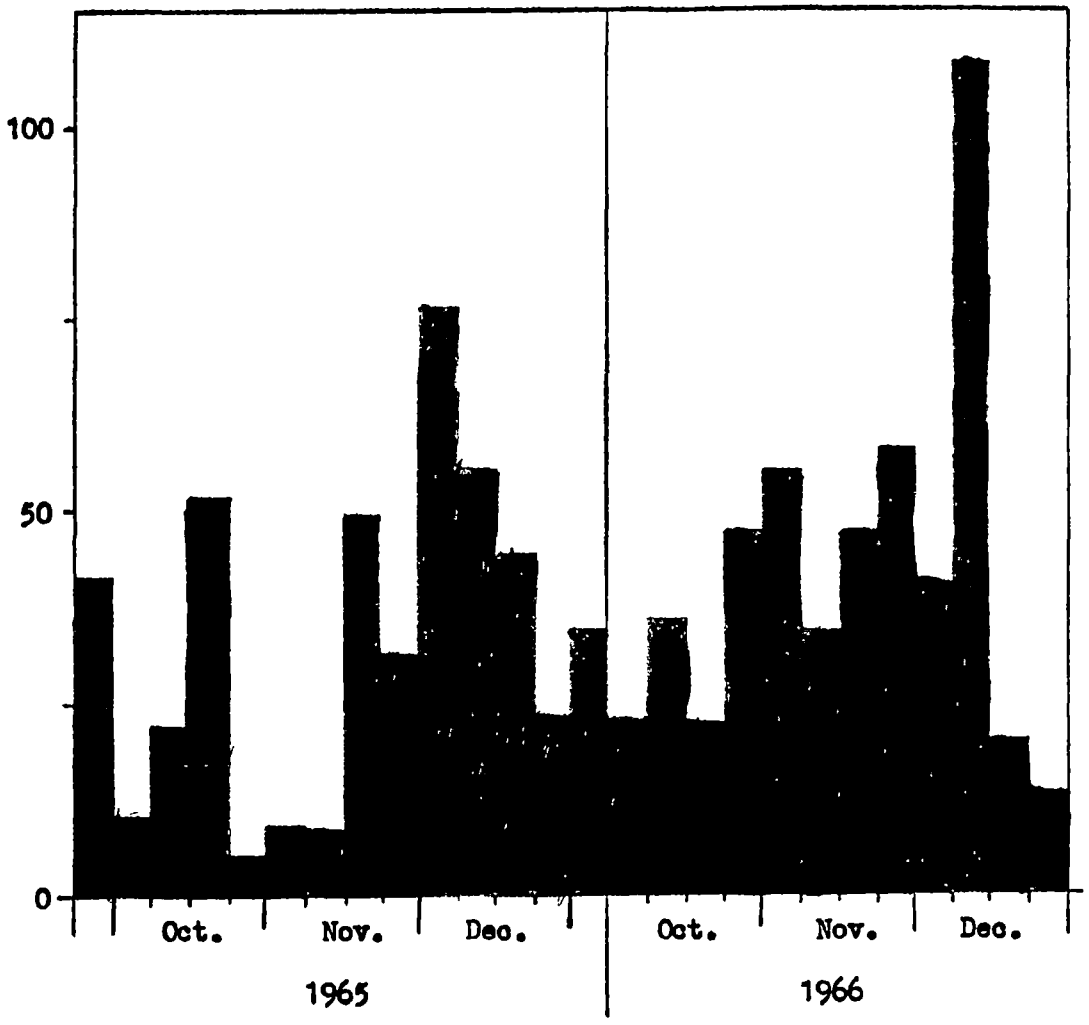


Fig. 25. Number of Fingerling Cutthroat Trapped per Week in Bar BC Spring Creek

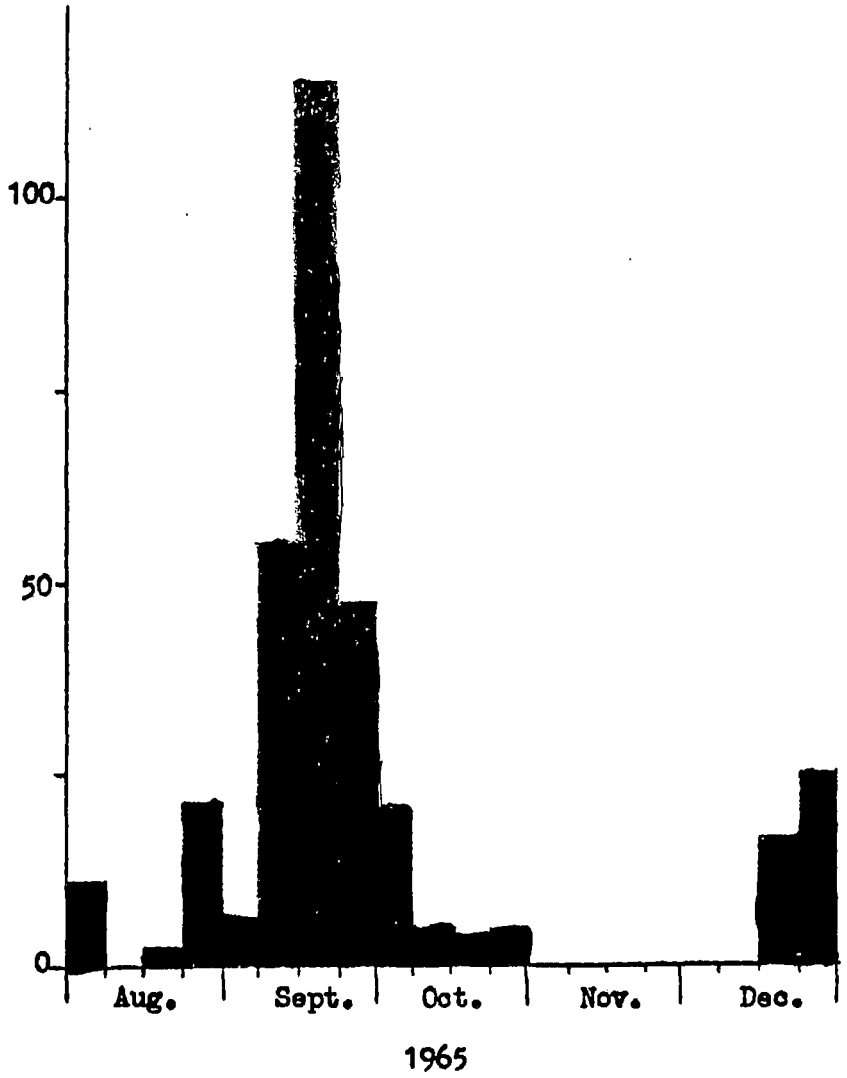


Figure 25 shows the number of cutthroat fingerlings trapped in Bar BC Spring Creek in 1965. Most of these trout were captured in a fry trap that was set downstream from the fish trap. The overpour trap was usually flooded out each morning by accumulated vegetation and most of the fry in the trap would then escape. The figure indicates a definite migration of fingerling cutthroat in September followed by a period of over two months were little migration occurred. Young-of-the-year cutthroat begam to move downstream again in late December, just before trapping was discontinued. It is not known what proportion of the cutthroat fingerling population migrated downstream in September, but it is doubtful that a majority of them did so. They could be seen in abundance throughout the lower portion of the creek from August through December and no apparent reduction in their numbers was ever observed.

Boussu (1954) reported that aquatic vegetation in Trout Creek, Montana, was extensively used as cover, particularly by smaller fish. Observations made during this study also indicated this to be the case. An attempt was made during this study to correlate the downstream migration of fingerling cutthroat in Bar BC Spring Creek with the regression of aquatic plants. In late December of 1964, most of the aquatic vegetation in the main channel of the creek was dislodged by cattle. A fence prevented these cattle from entering a small portion of the creek (including spring channel SC-3) and the vegetation remained relatively intact in this area. This spring channel and stream section 1A were electro-fished with a portable shocker on January 4 and 5, 1965. Only two fingerling cutthroat were captued in that part of the creek where the vegetation had been dislodged, but 28 fingerlings were captured in a short section of the spring channel where the vegetation was still intact.

Figure 26. Bar BC Spring Creek. Photograph taken October 7, 1964 showing the abundance of aquatic vegetation.

As indicated above, trapping of downstream-migrating cutthroat was not possible when vegetation was floating out of the creek, so other than this instance, no direct evidence of a relationship between downstream migration and reduction of cover was observed. It is still felt however, that the reduction of cover in Bar BC Spring Creek may have been a major factor in initiating winter downstream migration of young cutthroat.

In Blue Crane Creek, the largest daily downstream migrations were observed during extremely cold weather. For example, 191 cutthroat were trapped in the overpour trap on January 20, 1964 after the air temperature had dropped to -32 degrees during the night. Maciolek and Needham (1951) reported that trout in Convict Creek, California, did not show any tendency to move out of the study areas during cold weather. They further observed large daily fluctuations in water flow due to the formation and dispersion of anchor ice in the creek bottom. This fluctuation occasionally dried up side channels and caused some mortality of trout. Anchor ice and fluctuating water flows were not observed in Blue Crane Creek. The only apparent effect of extremely cold weather in this creek was the freezing up of shoreline and flow-water area which probably reduced the amount of habitat.

Growth of Cutthroat Trout Fry

Table 17 shows the average total lengths per week of age 0 and 0+ cutthroat that were measured at the fish traps. The average length of fingerling cutthroat in Bar BC Spring Creek and Fish Creek increased throughout the season. Benson (1960) reported that the average length of downstream-migrating cutthroat fry also increased throughout the season at the Arnica Creek fish trap. He further cited other studies where it was indicated that the size of immature salmonids may influence their downstream migration--that is, they must reach a certain size before they migrate downstream. The length data obtained at the Blue Crane Creek trap indicated

TABLE 17

Average Total Length by Week of Young-of-the-Year Cutthroat Total Trapped in Three Snake River Tributaries

Time Period Month - Week	Bar BC 1965-66	Fish Creek 1965-66	Fish Creek 1966	Blue Crane Creek 1962-63	Blue Crane Creek 1963-64	Blue Crane Creek 1964-65
8 - 1	0.90					
8 - 2						
8 - 3	1.13					
8 - 4	1.15					
9 - 1	1.30					
9 - 2	1.60					
9 - 3	1.64					
9 - 4		1.83				
10 - 1		1.44	2.00			
10 - 2		1.76	2.07			
10 - 3	2.04	1.94	2.11			
10 - 4	(2.37)*	1.74	2.24			
11 - 1		1.89	2.21			
11 - 2		1.89	2.16			
11 - 3		2.23	2.15	4.00		
11 - 4			2.19			
12 - 1		2.13		4.23	4.38	
12 - 2		2.18		4.11		
12 - 3		2.33		4.15	4.31	
12 - 4			2.43	4.07	4.40	
1 - 1	2.37	2.34		4.24	4.32	4.15
1 - 2				4.20	4.26	
1 - 3				4.09	4.17	3.96
1 - 4				4.03	4.20	3.91
2 - 1					4.22	
2 - 2				4.17		3.76
2 - 3				4.07	4.20	3.64
2 - 4				4.05	4.31	
3 - 1				4.08	4.18	3.80
3 - 2				4.19	4.25	4.07
3 - 3				4.15	4.02	4.16
3 - 4				4.24	4.03	3.92
4 - 1				4.36	4.80	3.92
4 - 2					4.77	4.03
4 - 3				4.52		
4 - 4				4.32		
5 - All				4.70	4.38	4.28

* Data obtained during 1966 electro-fishing work

this as it appeared that the faster-growing fingerling cutthroat were the first to migrate downstream. The average length of fingerling cutthroat decreased in January and February in 1963 and in January, February and March of 1964. This was not well indicated in the 1965 data, but samples taken in that year were much smaller than in the two previous years.

The increased average lengths in March and April are probably due to increased rates of growth. The average length of cutthroat fingerlings was greater in Blue Crane Creek than in the other two tributaries. It is likely that this is the result of earlier emergence and higher water temperatures in the summer. The average lengths of cutthroat in Bar BC Spring Creek and Fish Creek were similar and it is felt that the cutthroat fry in these creeks emerged at about the same time.

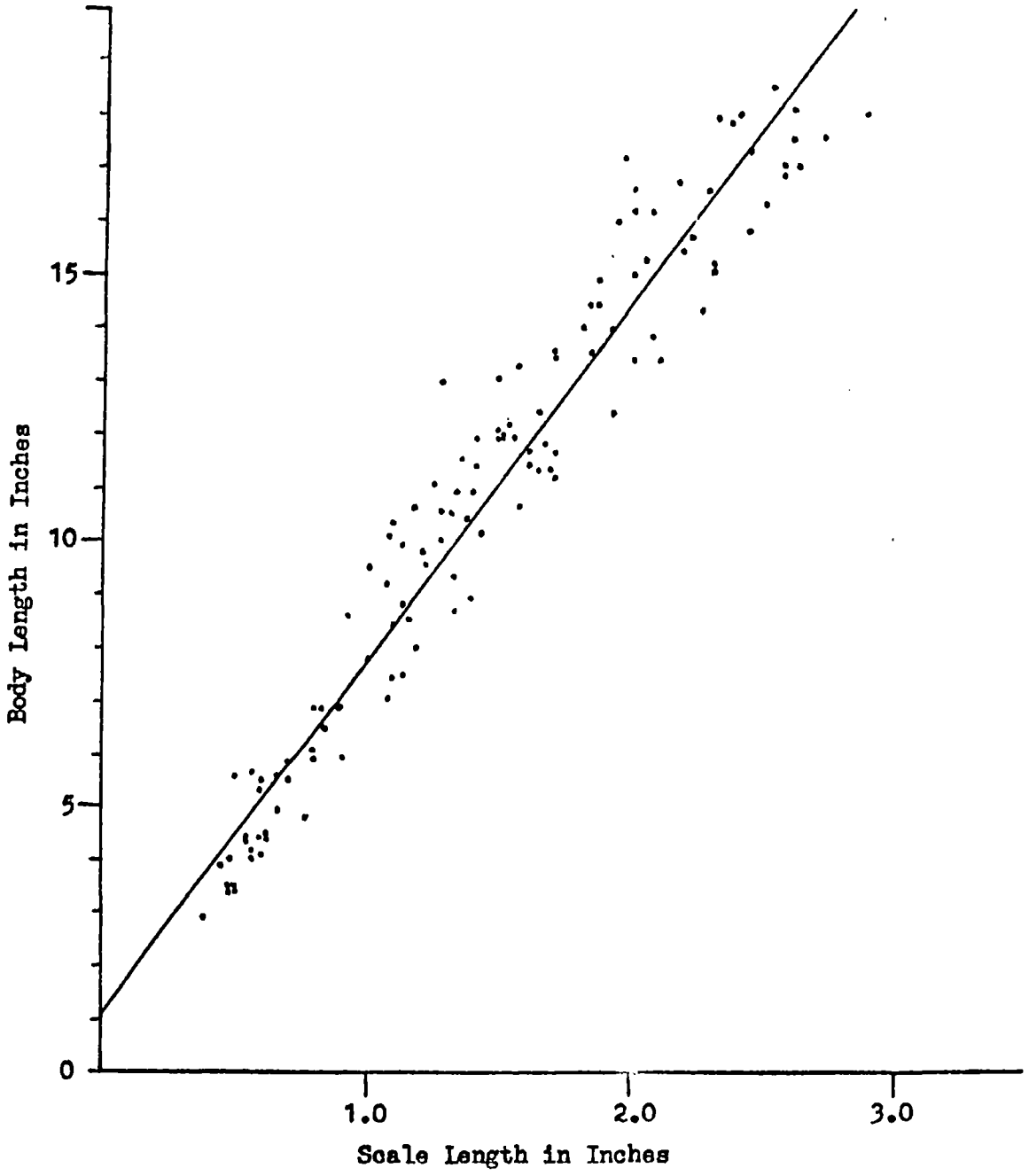
Upstream Migration of Immature Cutthroat Trout

In 1964, 183 immature age I and II cutthroat migrated upstream into the Blue Crane Creek trap during the spawning run. Fifty-five (30%) of these trout had been previously fin-clipped at the overpour trap. Similar smaller runs were observed in 1963 and 1965. In addition, twelve immature cutthroat were trapped while migrating upstream in Blue Crane Creek during November and December of 1963. The upstream trap was not operated at this time of year in 1962 or 1964. Benson (1960) mentioned that there was some upstream movement of age I and II cutthroat into Arnica Creek prior to installation of the fish trap in the spring.

Age and Growth of Cutthroat Trout

Figure 27 presents a scatter diagram and calculated line describing the relationship between body length and anterior scale radius length of cutthroat trout from Blue Crane Creek. The equation for the line was

Fig. 27. Relationship Between the Body Length and Anterior Scale Radius Length of Blue Crane Creek Cutthroat Trout



$L = 1.03 + 6.7565\ S$. Figure 28 indicates the relationship between length and weight of cutthroat trout from Blue Crane Creek. Table 18 presents the average total length and weight, and the calculated length and increment of growth of cutthroat trout from Blue Crane Creek.

Because the samples from Fish Creek and Bar BC Spring Creek consisted almost entirely of spawning cutthroat, no suitable calculated life history of these trout could be made. Table 19 presents the empirical length and weight of each age class of cutthroat trout from Fish Creek and Bar BC Spring Creek, and the empirical length of cutthoat trout from the Snake River. The Snake River data were obtained in 1958 by area fisheries managment personnel.

Most immature cutthroat from Blue Crane Creek formed an annulus on their scales in late April and early May. Many of the slow-growing immature cutthroat did not form an annulus until late May or early June. Among a group of young cutthoat sampled in May, 1965, from Blue Crane Creek, about ten percent had no annulus on their scales. The average length of those immature cutthroat that had formed no annulus was 3.7 inches while those cutthoat that had formed an annulus averaged 4.6 inches long. Annulus formation on the scales of spawning cutthroat was variable. Some cutthoat spawners formed an annulus in early May, but many others had not formed an annulus until July, or nearly one month after the spawning season in Blue Crane Creek.

Fig. 28. Length-Weight Relationship of Blue Crane Creek Cutthroat Trout

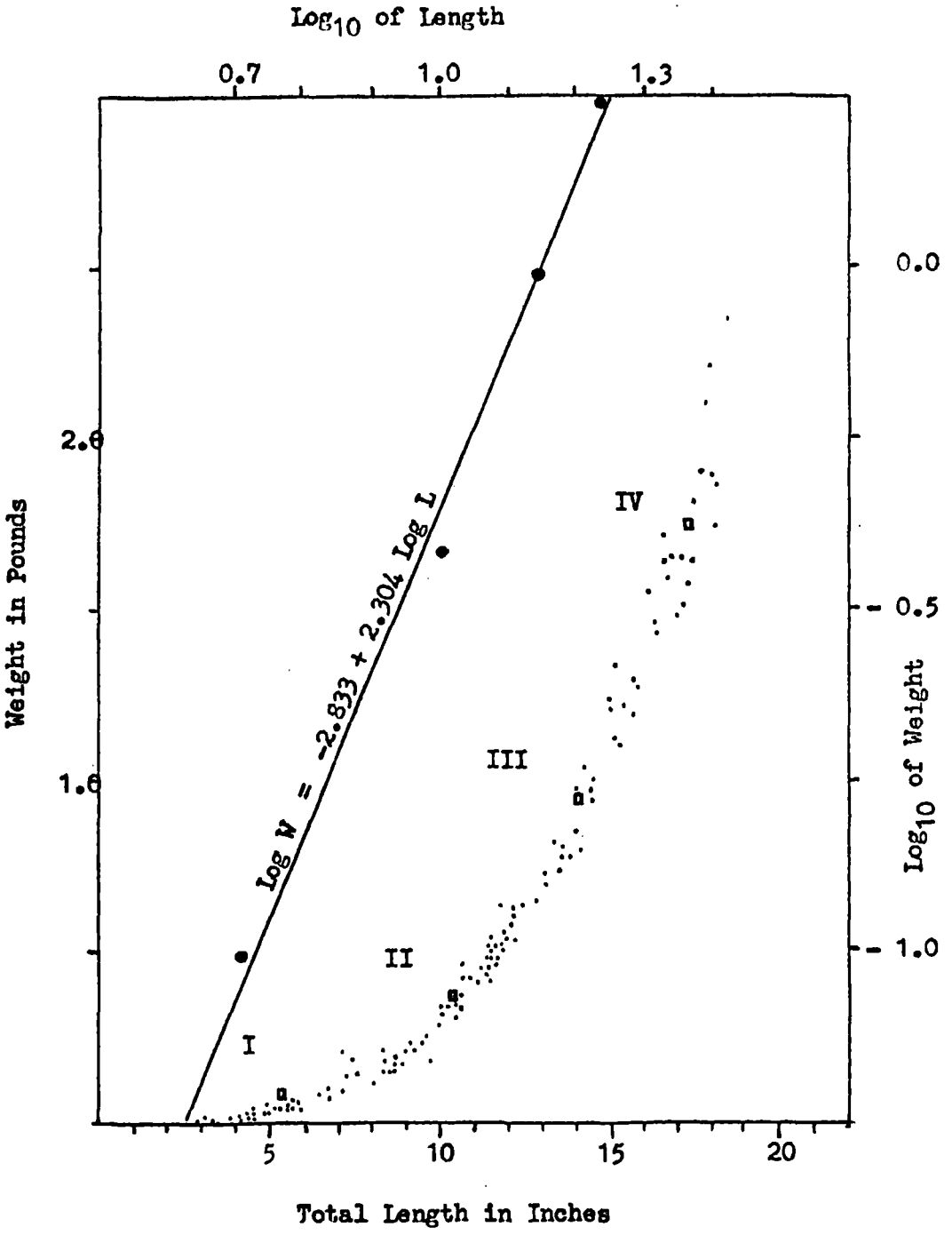


TABLE 18

Calculated Life History of Cutthroat Trout from the Blue Crane Creek

Age Class	Number	Average Length	Average Weight	I	II	III	IV
I	52	5.20	0.09	4.71	-	-	-
II	63	10.24	0.38	4.83	9.50	-	-
III	35	14.01	0.96	4.88	10.09	13.03	-
IV	17	17.27	1.75	5.08	10.62	14.79	14.00
Average Calculated Total Length				4.87	10.07	13.91	14.00
Annual Calculated Increment of Length				4.87	5.20	3.84	0.09
Average Calculated Weight in Pounds				0.056	0.301	0.623	0.643
Annual Calculated Increment of Weight				0.056	0.245	0.322	0.020

TABLE 19

Empitical Length and Weight of Different Age Classes of Cutthroat Trout from the Snake River and Two Tributary Streams

	Bar BC Spring Creek			Fish Creek			Snake River*	
Age Class	Number	Average Length	Average Weight	Number	Average Length	Average Weight	Number	Average Length
I	1	5.60	-	0	-	-	7	7.58
II	7	11.04	0.56	11	8.72	0.21	119	9.41
III	38	13.74	1.03	52	13.70	0.90	118	13.19
IV	29	16.63	1.81	26	17.43	2.04	32	15.23
V	10	18.66	2.72	5	19.70	2.94	6	15.80
VI	1	19.8	2.92	-	-	-	1	16.6

* Weights not obtained in the Snake River sample

SUMMARY

The spawning behavior of Snake River cutthroat trout in three tributary streams in Wyoming was investigated in this study. These streams, Blue Crane Creek, Fish Creek, and Bar BC Spring Creek, were low gradient, productive streams known to be utilized by Snake River cutthroat trout for spawning. Water temperatures were less variable in Bar BC Spring Creek than in the other two creeks. Winter water temperatures in all three tributaries were warmer than those in the Snake River. The 1965 run-off in the Snake River was higher than normal while the 1966 run-off was lower than normal.

Observations made at Blue Crane Creek indicated that most cutthroat spawning occurred during April. Cutthroat spawned in Fish Creek in late April, May and June. Most cutthroat spawning occurred during June and early July in Bar BC Spring Creek.

All three tributaries contained extensive areas of suitable gravel. Snake River cutthroat preferred to spawn in gravel of from one to two and one-half inches in diameter. Many areas of suitable gravel were not utilized and superimposition of spawning occurred in at least two areas.

Reliable information on the total numbers of spawning cutthroat was obtained in Bar BC Spring Creek where 234 spawned in 1965 and 136 spawned in 1966. A well-defined cutthroat spawning run was not observed in Blue Crane Creek. Because of high water overflowing the trap, only trend data could be obtained of the number of cutthroat trout spawning in Fish Creek.

The sex ratio of cutthroat spawners in all tributaries varied from one male per 1.3 females to one male per 0.7 females for several years.

Most ratios did not vary much from one to one where adequate samples were obtained. Female cutthroat tended to migrate into Fish Creek and Bar BC Spring Creek somewhat later than did male cutthroat.

In 1965, 87.4 percent of the Fish Creek cutthroat spawners and 84.4 percent of the Bar BC Spring Creek spawners were age III and IV. The majority of cutthroat males were age III while the majority of cutthroat females were age IV.

Estimates of post-spawning mortality of cutthroat spawners in Bar BC Spring Creek were 45.6 percent in 1965 and 53.5 percent 1966. Twenty-one (9.4%) of the total number of 1965 Bar BC Spring Creek cutthroat spawners spawned again in 1966. Of these, ten were females and eleven were males. Of six tagged repeat cutthroat spawners captured in the 1965 Blue Crane Creek spawning run, five were consecutive spawners and one was an alternate spawner. Numerous instances of homing behavior were observed during this study and three instances of straying between the three study tributaries were also noted.

Fish population estimates made in sections of Fish Creek were used only as trend data. Young-of-the-year cutthroat comprised 89.6 percent of the cutthroat trout population in downstream study sections of Fish Creek, and hatchery cutthroat comprised 13.2 percent of the total cutthroat population in the same area. The number of wild young-of-the-year cutthroat in these downstream sections declined from 1964 to 1966.

The total fish population in Bar BC Spring Creek was estimated to be 3,439 in 1964, 6,640 in 1965, and 4,554 in 1966. Brook trout were the most abundant resident species in this creek. Most cutthroat trout migrated out of Bar BC Spring Creek sometime during their first winter. In 1965 and 1966, young-of-the-year cutthroat made up 77.8 and 66.8 percent of

the total fish population, while older cutthroat made up 2.3 and 0.8 percent of the total fish population.

Sixteen female cutthroat that were killed for fecundity analysis contained an average of 2,308 eggs per female. Mortality of cutthroat trout eggs from 17 redd samples varied from 1.8 to 74.3 percent in Bar BC Spring Creek. The average mortality of ten redd samples containing more than 100 eggs per redd was 4.4 percent.

The total mortality of cutthroat trout fry from the time of hatching through October in Bar BC Spring Creek was calculated to be 97.89 percent in 1965 and 97.68 percent in 1966. Because of downstream migration of cutthroat trout fry in September 1965, it is felt that these estimates of fry mortality may be high.

Immature cutthroat trout migrated out of Blue Crane Creek to the Snake River during the winter. Age I and I+ cutthroat comprised 46 percent of the total number of cutthroat trapped while moving out of this creek. Analysis of length data obtained from young-of-the-year cutthroat migrating out of Blue Crane Creek indicated that the faster-growing cutthroat were the first to migrate downstream. In Fish Creek, fingerling cutthroat migrated into the downstream traps throughout the fall and early winter. Few age I and II cutthroat were observed to migrate downstream at this time. An increase in the number of downstream-migrating cutthroat was observed in December of 1965 and January of 1967 indicating that the migration in Fish Creek continued for sometime into the winter. Only trend data were obtained on the downstream movement of fingerling cutthroat in Bar BC Spring Creek. There was a definite downstream movement of young-of-the-year cutthroat in this creek in September, 1965. Stream observations indicated that most fingerling cutthroat migrated

out of Bar BC Spring Creek in December and January.

Cutthroat fingerlings migrating downstream in Blue Crane Creek averaged nearly two inches longer than those migrating downstream in Fish Creek and Bar BC Spring Creek. A number of age I and II immature cutthroat were observed migrating upstream in Blue Crane Creek during the spawning runs.

The body length-scale length relationship of Blue Crane Creek cutthroat trout was a straight line described by the equation $L = 1.03 + 6.7565\ S$. Most immature cutthroat formed an annulus on their scales in late April or early May. Annulus formation on the scales of cutthroat trout spawners was more variable.

CONCLUSIONS AND RECOMMENDATIONS

The three Snake River tributaries investigated during this study provided excellent spawning and nursery areas for cutthroat trout. In both Fish Creek and Blue Crane Creek, resident cutthroat were a large but unknown portion of the total spawning fish. Bar BC Spring Creek had few resident adult cutthroat and migrant spawners made up the great majority of spawning fish. Extensive areas of aquatic vegetation in all three creeks provided excellent habitat for young-of-the-year cutthroat trout during the late summer and fall.

Comparatively small numbers of cutthroat trout migrated out of the Snake River and through the fish traps in the three creeks. Access into the mouth of Blue Crane Creek had been blocked for five years prior to 1962 and a well-developed spawning run did not develop during the investigation. It is felt that the number of cutthroat trout spawning in Fish Creek was greater than the trap records indicated. Evidence of spawning activity downstream from the fish trap was observed after high water in 1965 and several other observations indicated that cutthroat continued to migrate upstream to spawn during June after the fish trap was removed. Good data were obtained on the size of the Bar BC Spring Creek spawning runs in 1965 and 1966. Consecutive spawning by Snake River cutthroat trout is higher than that reported in other studies.

It is felt that all three tributaries would be able to support larger spawning runs than were observed during this study. Large areas of suitable spawning gravel were not utilized by spawning cutthroat and areas of suitable habitat for fingerling cutthroat were abundant. It is felt that any effort that would increase the number of cutthroat spawners in these streams would

ultimately benefit the Snake River fishery.

Young-of-the-year cutthroat in all three creeks migrated downstream during the fall and winter. Some downstream migration of cutthroat fingerlings was detected in Bar BC Spring Creek in September of 1965, but no such movement was found in Blue Crane Creek or Spring Creek. Fingerling cutthroat migrated downstream through the Fish Creek trap throughout the fall and early winter of 1965 and 1966. The fish trap was not installed until late September in 1965 and early October in 1966 and nothing is known of downstream movement prior to this time. Trapping data obtained from an overpour trap operated in Horse Creek from 1960 through 1963 indicated that the peak of downstream migration of cutthroat fry was in September. This creek is more typical of most Snake River tributaries in that it drains a mountainous area and has a very large annual fluctuation. It is felt that a late fall or early winter downstream migration of cutthroat fingerlings is probably a feature of low-gradient, spring-fed tributaries such as the three that were studied.

Information obtained at Bar BC Spring Creek suggested that young-of-the-year cutthroat migrated downstream when the cover of aquatic vegetation broke up. It is suggested that the reduction of aquatic vegetation is a factor in initiating downstream migration.

In Bar BC Spring Creek, survival of cutthroat trout eggs was about 95 percent and survival of cutthroat fry to the fingerling stage was estimated to be less than 3 percent. This estimate of fry mortality is probably somewhat high, but it is apparent that naturally-spawned cutthroat trout suffer high natural mortalities during or shortly after emergence from the gravel. In 1966, the survival of hatchery fingerling cutthroat in Fish Creek appeared to be good. Two months after being released, they comprised 13.2 percent of the total cutthroat population in the downstream study area and 13.6 percent of the total catch of young-of-the-year cutthroat trapped in the overpour trap.

It is recommended that the present program of releasing fin-clipped hatchery fingerling cutthroat in Fish Creek be continued. The survival and subsequent contribution of these fish to the cutthroat spawning run should be evaluated through operation of the fish trap or by electro-fishing during the fall. It is also recommended that similar releases be made in Bar BC Spring Creek as was done in 1964. The contribution of these fish to future spawning runs should be evaluated by operating the fish trap during the spawning period.

It is also recommended that the information on spawning potential of all Snake River tributaries between the Wyoming-Idaho state line and the Jackson Lake dam be updated. All efforts should be made to prevent any further loss of spawning areas in tributary streams to the Snake River, and where possible, efforts should be made to improve present spawning areas.

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